United States
Department of
Agriculture

Forest
Service

Northern
Region

Minerals, People and Dollars

Social, Economic and Technological Aspects of Mineral Resource Development

Cover:

Lower Burke, Idaho, showing Hecla Mine, 1910

#8-X38
Barnard-Stockbridge Collection
University of Idaho Library
Moscow, Idaho

MINERALS, PEOPLE AND DOLLARS
Social, Economic and Technological Aspects of Mineral Resource Development

September 1992

by
Lambert N. Wenner
Consultant
Social and Environmental Impacts
Salem, Oregon

R1-92-133

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PREFACE

Public lands in the United States contain a sizable portion of the Nation's undeveloped mineral deposits. U.S. mining laws permit citizens and domestic corporations to explore and to develop the mineral resources of most public lands, and there is growing interest in the numerous deposits of metallic ores, petroleum, and industrial minerals on National Forest System lands. The Forest Service has expanded its minerals program to increase employee proficiency in minerals management, to process the growing number of lease and permit applications and proposed operating plans, and to manage land surface impacts.

The National Environmental Policy Act of 1969 (NEPA) and the National Forest Management Act of 1976 (NFMA) direct federal agencies to consider social, economic, physical, and biological effects of programs which affect the human environment. Social and environmental issues are increasingly important because of intensified public interest in both environmental quality and public land use. In response to these needs, and to overcome large gaps in existing information, the USDA Forest Service, Northern Region, developed a series of information and guidance documents for Forest and Regional use, including:

- *Northern Region Oil and Gas Guide, 1979*
- *Socioeconomic Assessment Bibliographies for Minerals Activities, 1979, 1980*
- *Survey of the Social and Economic Effects of Oil and Gas Development: Little Missouri National Grasslands, 1980*
- *Oil and Gas Activity in the Northern Region, 1980, 1983*
- *The Outlook for Mineral Resources in the Northern Region, 1981*
- *Social and Economic Assessment of Oil and Gas Activities, 1979, 1981*
- *Minerals, People, and Dollars: Social, Economic, and Technological Aspects of Mineral Resource Development, 1982, 1984*

Although these publications were initially developed for agency use, public, other agency, and industry demand was unusually strong and reprints and revisions were soon necessary. The present document, a revision of the last in this series, is a primer on minerals, mining technology, environmental protection procedures, and the social and environmental consequences of mineral operations. It is written in nontechnical prose for Forest Service employees, cooperating agencies, and other interested groups. It introduces the reader to the world of minerals (Chapter 1) through a discussion of their origins, variety, and uses. It then describes the mining industry and its activities using examples from the states of the Northern Region. Brief scenarios of each type and stage of operations are presented, first to demonstrate the planning and technology requirements (Chapter 2) and then to display potential social benefits and costs (Chapter 4).

Chapter 3 identifies variables that influence the type and magnitude of social and environmental effects generated by mineral activities. It includes a review of the environmental analysis and documentation procedures required by the National Environmental Policy Act and Forest

Service policy, before potentially impactive activities can be approved. Chapter 5 summarizes public and agency concerns and provides suggestions for mitigating adverse effects.

The principal author of this second edition is Dr. Lambert N. Wenner, Sociologist, recently retired from Programs and Legislation in the Chief's Office. Dr. Wenner prepared the original text of the first edition in 1982, while assigned to the Minerals and Geology Staff Unit in the Northern Region. This draft document was finalized in 1984 by Michael Burnside (Geologist) and Norman Yogerst (Soil Scientist), of this staff unit, with the assistance of Richard Marshall and Dr. Wenner. All four had considerable experience writing and reviewing minerals impact-related documents, including those in the list above, and had served on numerous interdisciplinary teams for both environmental analyses and special studies of Northern Region and interagency mineral projects and programs.

Richard Marshall coordinated development of the 1992 edition and provided information on mineral economics and on the socioeconomic impacts of the Stillwater Mine project. Other specialists who reviewed and critiqued sections of this 1992 revision included Mike Burnside, focusing on minerals and geology; Leslie Vaculik, on petroleum operations; Norm Yogerst, on environmental procedures; Jim Shelden, on industrial minerals; and Charles Wassinger, as Director of Lands and Minerals, Northern Region. Cathy Thompson, Betty Dee Russ, and Christine Jones deserve special recognition for their efforts in graphics presentation, typing, and layout of the final manuscript. Carol Evans designed the cover and drew several of the illustrations.

Rather little professional literature describes communities impacted by the hard rock mining and industrial minerals industries, so it was necessary to make many inferences from recent studies of energy development. To gain additional information for the first edition, the author visited several mining and petroleum producing areas of Montana, Idaho, and North Dakota and conducted interviews with over 100 residents. Chapters 3 to 5 are based in part on these findings. The reader who seeks additional information on impact assessment methods, effects estimation techniques, or the results of specific community studies should consult the bibliography.

A word of appreciation is also due to those who helped to prepare the first edition of this document, including Billy Hicks, Geologist; Arnold Holden, Sociologist; Dave Kapaldo, Economist; and John Nichols, Geologist. Information on Northern Region mineral activities was supplied by Brian White, Mining Engineer; Sherm Sollid, Geologist; Joe Spehar, Resource Officer; and Bill Ferrell, Resource Officer. Gary Morrison, Geologist, provided data on mineral potential in the Northern Region. Bob Newman, Mining Engineer; John Nichols, Mining Geologist; and Mike Burnside, Geologist, helped to clarify technical and policy issues. Buster LaMoure, Minerals Staff Director, supported and encouraged the project. Most illustrations were drawn by Dee Williams, Graphic Artist. Toni Lay provided logistical support and Suzette Dailey typed both the draft and final manuscripts.

The selection of information for inclusion, the analysis of this information, and any personal impressions of mineral activities or their effects are intended to be informational and descriptive. Any opinions expressed or implied are those of the author. The document is not an official statement of Forest Service position or policy.

CHAPTER 1:
Mineral Resources

Most Americans, both rural and urban, are extremely dependent on hundreds of minerals, yet know rather little about them. People usually recognize minerals products (as distinct from wood, animal, or vegetable products), but even this can be difficult. Plastics or fabrics, for example, are manufactured from mineral, plant, or animal substances. Amber and coal are largely of plant origin.

MINERALS DEFINED

The concept "mineral" is used in several different ways. In technical usage, minerals are naturally-occurring inorganic substances of relatively fixed composition. Some authorities limit the use of the term to crystalline solids, while others include substances such as mercury, water, and even gases. In common usage, "mineral resource" is applied to almost any homogeneous component of the earth's crust, including various rocks, industrial minerals, metals, geothermal resources, and fossil fuels such as oil, gas, and coal.

In this document, "mineral" includes any material from the earth's crust that might be used in home or industrial applications. Modifiers are used to denote materials of organic origin; e.g., mineral or fossil fuels. This broad conception encompasses over 3000 different substances including most of the 106 known elements (a few are laboratory creations) and numerous compounds, singly or in combination.

All elements and many mineral compounds extracted from more complex materials are utilized by humans. More than a hundred of these are major commodities in international trade and are the raw materials used to manufacture literally tens of thousands of widely-used consumer products.

Looking around from an office desk, one sees numerous examples of mineral commodities. Most obvious are the metal products: typewriters, staplers, calculators, file cabinets, aluminum window frames, heat ventilators, bookcases, and the desk itself. But other minerals abound. Above and below are fiberglass ceiling tiles and nylon carpets. The building itself consists of brick, stone, concrete, glass, and gypsum board. It is outfitted with copper wiring and plumbing, and ceramic and metallic fixtures. An expanding array of mineral materials is used in homes, factories, schools, modern transportation, utilities, agriculture, medicine, national defense, space exploration, and other sectors of human activity.

Nature and Origin

Scientists theorize that the basic elements of matter are created from hydrogen and helium in the nuclear furnaces of evolving stars. The intense heat and enormous pressure permit the formation of different elements with distinctive physical characteristics. When planets are formed from fragments of a star, the number, quantity, and quality of these elements are relatively fixed,

except for radioactive substances which continue to change at a very slow rate.

The basic chemical elements seldom exist in a pure or free state. Usually they are locked in molecular compounds with other elements. These compounds are mixed or concentrated with other compounds by various rock-forming processes in the earth's mantle or crust. This may obscure the identity of specific minerals and increase the difficulty of locating and extracting them.

Planetary forces, such as continental drift, gravity, heat, wind, water, volcanic activity, earthquakes, the actions of living organisms, and chemical activity, continually alter the earth's crust. Subterranean materials are transported to the surface; rock structures and compounds are decomposed; loose materials and liquids move to new locations; and new surface features result.

Geologists find an extremely great variation in the relative abundance of the minerals that make up the earth's crust. Eight of the known elements combine readily to form compounds with others and together account for about 98 percent of the crust's volume. Oxygen is the most plentiful (47 percent), followed by silicon (28 percent), aluminum, iron, and calcium (Table 1-1).

Mineral Categories

More than 100 minerals (Table 1-2) are almost indispensable in modern life. Extracting, producing, and marketing minerals has become a multibillion dollar business in many nations of the world, and the value of crude minerals production approached $2 trillion in 1990.[1/] Some minerals are merely extracted, processed to remove impurities, and crushed or milled to a uniform size for use in construction and landscaping, or as a fuel, fertilizer, or abrasive. Sand and gravel, building stone, coal, phosphate, pumice, corundum, and salt are examples. But most minerals are separated into more basic components, such as metals, fuels, or chemicals, or are

Table 1-1
Relative Abundance of Selected Elements: Percentage of Earth's Crust

Oxygen	46.6	Titanium	.4	Chromium	.01	Molybdenum	.0001
Silicon	27.7	Hydrogen	.1	Nickel	.007	Tungsten	.0001
Aluminum	8.3	Phosphorus	.12	Zinc	.007	Iodine	.00005
Iron	5.0	Manganese	.09	Copper	.005	Antimony	.00002
Calcium	3.6	Sulfur	.03	Cobalt	.002	Mercury	.000008
Sodium	2.8	Carbon	.02	Nitrogen	.002	Silver	.000007
Potassium	2.6	Vanadium	.01	Lead	.001	Platinum	.000001
Magnesium	2.1	Chlorine	.01	Tin	.0002	Gold	.0000004

Source: Adapted from Brian Mason, Principles of Geochemistry, 3rd edition. New York: John Wiley, 1966, pp. 45-46. Rand McNally's Atlas of Earth Resources, 1979, provides slightly different estimates for most of these and demonstrates how oceanic and continental crusts differ in their average composition.

[1/] Very readable background sources on minerals include: Cargo, David N. and Bob F. Mallory. Man and His Geologic Environment. Reading, Mass.: Addision-Wesley Publ. Co., 1974; McDevitt, James F. and Gerald Manners, Minerals and Men, 2nd Ed. Baltimore: Johns Hopkins Press, 1974.

Table 1-2
Categories of Mineral Resources

METALS		NONMETALLIC INDUSTRIAL MINERALS		
Metals Used in Iron Alloys		Building Material		Fertilizers
Iron Ore	Molybdenum	Cement		Guano
Chromium	Nickel	Gypsum		Lime
Cobalt	Tungsten	Limestone		Phosphate
Columbium	Vanadium	Perlite		Potash
Manganese		Sand & Gravel		
		Stone, Crushed		Pigments & Fillers
Base Metals		Stone, Dimension		Barite
Antimony	Lead			Bentonite
Bismuth	Tin	Insulation		Clays
Cadmium	Zinc	Asbestos		Kaolin
Copper		Mica		Talc
		Vermiculite		
Light Metals				Gem Stones
Aluminum		Abrasives		Beryl
Magnesium		Corundum		Diamond
Titanium		Flint		Emerald
		Garnet		Opal
Precious Metals		Industrial Diamonds		Sapphire
Gold		Pumice		
Platinum Group				Decorative Stones
Silver		Ceramic Materials		Granite
		Calcite, Optical		Marble
Rare Metals		Clays		Obsidian
Beryllium		Feldspar		Petrified Wood
Radium		Fluorspar		Slate
Uranium		Glass Sand		Travertine
		Quartz		
Other Metals				Water
Mercury		Chemicals (Diverse Uses)		Surface Water
		Arsenic	Lithium	Aquifers
FOSSIL FUELS & GASES		Boron	Salt	Geothermal Sources
Coal		Bromine	Silicon	Hydropower Sources
Natural Gas		Carbon	Sodium	
Peat		Cesium	Sulfur	Other
Petroleum		Chlorine		Amber
Shale Oil		Fluorine		Fossil Plants, Animals
Synthetic Gas		Graphite		Topsoil
Argon				
Carbon Dioxide				
Helium				
Hydrogen				
Neon				
Nitrogen				
Oxygen				

transformed through chemical and metallurgical processes into products for personal and industrial use.

Metallic Minerals. Among the nonfuel minerals, metals are especially valuable because of their many industrial applications and, in some cases, their rarity. Most metals are strong, ductile (easily shaped), fusible (readily melted together), and efficient conductors of heat and electricity. Each has some unique qualities suited to particular product needs. A metal may be selected because it is tough, springy, resistant to corrosion or heat, flammable, lustrous, malleable, or alloys well with other elements to form compounds with desired properties.

Iron is presently the most vital and widely used mineral because of its great strength, relative abundance, and the capacity to alloy with many other elements, greatly extending its utility. The U.S. uses several times more iron (by weight) than all other metals combined. About 90 percent of iron is sold as carbon steel, which contains enough carbon to permit tempering and thereby increases the metal's hardness. Cast iron with additional carbon and silicon added is hard and brittle, but quite fusible. Pure iron is relatively soft and malleable.

Many comparatively scarce metals are increasingly important in alloys. A small amount added to steel greatly enhances its properties of strength, hardness, heat resistance, and/or corrosion resistance. Stainless steels containing chromium, nickel, tungsten, or vanadium are familiar examples. Manganese is used both as a catalyst in smelting iron ores and as an alloy of iron. The portion (by weight) of the rarer metal(s) needed for each steel alloy varies from a small fraction of 1 percent (boron) to as much as 27 percent (chromium), but is usually around 1 or 2 percent.

Base metals, such as copper and zinc, (Table 1-2) usually occur in compounds of sulfur, oxygen, and/or carbon and occasionally exist in concentrations rich enough to mine profitably. They have been collected and used since ancient times. Base metals are very malleable and durable. They often occur together in ores and blend easily with each other to form metal compounds with desirable properties. Common examples are brass (copper with zinc), bronze (copper with tin), and pewter (often tin with lead).

The precious metals are sometimes found in a pure state and have been used for jewelry and coins since ancient times. These metals are highly valued because they are rare, usually chemically inert (corrosion resistant), and very malleable. Because of their great worth, very little of the world supply is discarded each generation and new discoveries add to the total supply.

Aluminum, the most abundant metal in the earth's crust, is now cheaply produced with an electrolytic process and is second only to iron in demand. Its light weight, resistance to corrosion, good conductivity, and the strength of its alloys assure its widespread use in aircraft, construction, appliances, automobiles, machines, kitchen utensils, and portable equipment.[2/] Both precious and light metals have only recently been produced in large quantity due to the difficulty of separating them from native ores.

Industrial minerals. This is a catch-all category for a wide variety of nonmetallic, nonfuel minerals used in manufacturing chemicals or as basic

[2/] Detailed discussions of metals and industrial minerals are found in USDI Bureau of Mines publications, including: Mineral Commodity Summaries, published annually, Minerals Yearbook, published annually, and Minerals Facts and Problems, 1975, 1980, 1985.

materials in the construction, automobile, petroleum, textile, and other industries. Industrial minerals vary in value from diamonds to gravel and include such diverse materials as sulfur, borax, clays, phosphate, salt, talc, mica, quartz, granite, slate, and marble.

Some industrial minerals are called "common varieties" because they are both abundant and available in many parts of the world. Often they require only limited processing to be usable and are cheap enough to permit many applications. Construction materials, such as sand and gravel, account for about 60 percent of the value of all industrial minerals.

For a number of reasons, the demand for these minerals on public lands is increasing. Urban areas are expanding and the nearby existing sources are becoming depleted, forcing the search for new supplies out of the urban valleys and onto Forest Service lands. Improved transportation systems, including better Forest, state, and county roads, are making more sites on National Forest land attractive from an economic standpoint. Building trends are emphasizing durable, low maintenance construction materials, which favor, for example, building stone. Also, stone is often a material of choice in the construction of more expensive houses, and the market for those homes has fared somewhat better than other market segments during the current building lag.

Other factors stimulating the demand for common variety minerals (also known as mineral materials) include the reconstruction of local infrastructure (e.g., streets, highways) in rural communities and the construction and reconstruction of recreation-related facilities and roads on National Forest lands. In addition, technological changes have resulted in the greater use of mineral materials with one example being the higher mineral filler content in some plastic and paper products.

Fuels. Mineral fuels include fossil fuels (crude oil, natural gas, coal, and peat), synthetic fuels (methane, butane, propane, or other fuels derived from fossil fuels), uranium (a radioactive metal), and oil from shale and tar sands that are saturated with fossil fuels. Energy is also derived from water sources (geothermal, hydropower, tidal, etc.).

Petroleum is the most widely-used mineral fuel, supplying 41 percent of U.S. and roughly 38 percent of world demand for commercial energy. Coal is second, meeting 23 percent of U.S. and about 30 percent of world demand in 1988. The U.S. has abundant coal supplies (Figure 1-1) and domestic consumption has generally increased since the sharp escalation of oil prices in the mid-1970s. Natural gas is third, supplying about 24 and 20 percent respectively.[3/]

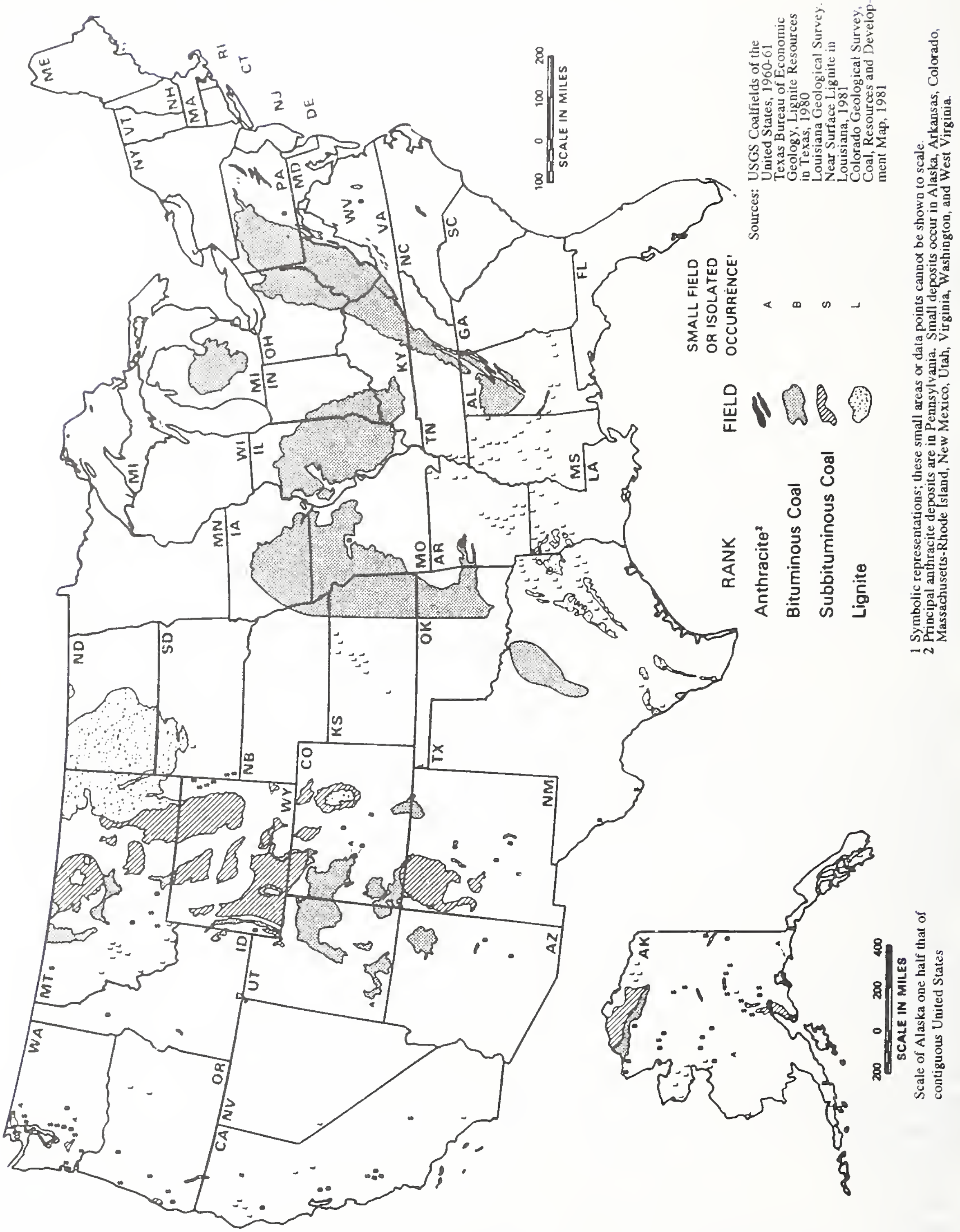
Other commercial energy sources play relatively minor roles, accounting for 11 percent of the U.S. and about 12 percent of world supplies. The leading forms are hydroelectric and nuclear power, still well ahead of wind, solar, geothermal, synthetic fuel, and other energy sources not mentioned above.

In addition to mineral fuels, biomass materials such as wood, animal dung, crop residues, and garbage are also widely used and are under increased scrutiny as supplementary fuels. Much biomass consumption is noncommercial and unrecorded but is estimated to supply about 6 percent of the world's energy demand.[4/] It contributes a smaller percentage in most industrial

[3/] Compiled from U.S. Department of Energy, Monthly Energy Review, April 1981; Energy Administration Data in U.S. Statistical Abstract, 1979; and Exxon Corporation, World Energy Outlook, December 1979.

[4/] U.S. Dept. of State and Council on Environmental Quality. Global 2000 Report to the President. New York: Pergamon, 1980.

Figure 1-1 **Coal-Bearing Areas of the United States**



Source: National Coal Association, Facts About Coal, 1991

countries, yet it remains significant in some rural areas of the U.S., including Idaho and Montana. About 5 million U.S. households burn wood as their primary fuel and wood supplied about 3 percent of the nation's energy in 1987. The demand for "alternative" fuels is expected to increase when oil and gas prices exceed other fuels.

Large quantities of mineral fuels are necessary for mining, transporting, and processing other mineral commodities. Energy availability is often a major consideration in selecting sites for mills, smelters and refineries.

MINERAL RESOURCE POTENTIAL

Several of the mineral commodities useful to humans are widely distributed on the earth's surface and also occur in concentrations that permit their use without extensive processing. Examples include building stone, sand, gravel, clays, chalk, sulfur, salt, and coal. Most other minerals are also widely distributed, but only occasionally exist in the concentrations necessary to make mining economically feasible. The world's reserves of some minerals are confined to four or five countries, as in the case of gem diamonds, boron, chromium, platinum, and trona.

With four exceptions (aluminum, iron, magnesium, and titanium), each metallic element is less than 0.1 percent of the earth's crust. Metals are seldom found in a pure state and even then usually exist as isolated particles in host rocks or gravels. Almost all metal is extracted from ores, that is, from rocks with mineral concentrations great enough to justify mining. Just how rich an ore must be depends on such factors as the value of the metal; the quality, size, shape, and accessibility of the ore body; labor, energy, and transportation costs; and the current state of mining technology. In the U.S. in 1900, copper concentrations of 6 percent or more were required to mine, but today the average mine processes ores with metal concentrations of 0.7 percent or less.

Metallic ores, minerals fuels, and many industrial minerals tend to be scattered in mineralized zones that vary in their geologic composition and surface features. Mineral deposits are frequently found where:

- the earth's crust is unstable, and minerals associated with igneous rocks have been intruded, exposed, or shifted to accessible locations.

- fast-flowing streams have slowed their pace and deposited flakes and nuggets of certain rare metals (gold, platinum, tin) or quantities of gemstones.

- water or glacial action has left layers of useful sediments (clays, sand, gravel).

- ancient swamps or seas have left extensive deposits of organic material which have been transformed into other substances (oil, gas, coal, amber, limestone, petrified wood) by heat, pressure, and chemical action.

Classifying Deposits

Over the years, a mining vocabulary has evolved[5/] to permit an increasingly precise description of the quantity, quality, and degree of certainty of U.S. and world mineral resources. In 1976, the U.S. Geological Survey and Bureau of Mines adopted a system for classifying known and

[5/] U.S. Dept. of the Interior, Geological Survey Circular 831, 1980, or USDI Bureau of Mines, Mineral Commodity Summaries, 1991, for details on definitions adopted in 1976.

prospective mineral wealth on the basis of (1) the extent of available geologic information about an area's potential and (2) the economic feasibility of development at a given time. Revised in 1981, this system defines 16 different resource categories (Figure 1-2).

Key concepts in this system of classification are resources, reserves, and economic. A resource is a naturally occurring concentration of solids, liquids, or gases that is economically feasible to extract, now or in the foreseeable future. A reserve is that portion of the resource which can be extracted economically at the time it is assessed. Economic means that it can be extracted at a profit.[6/]

This classification system is potentially useful in agency planning and scenario construction, but data are usually incomplete and, when available, must be regularly updated. Marginal reserves and subeconomic resources may become economic at some future date when mining technology is improved or mineral prices increase more rapidly than mining costs. Additional exploration data may require the reclassification of certain inferred reserves or undiscovered resources. Alternatively, a portion of a nation's resources (including reserves) may be withdrawn from mining by laws, regulations, or agency land-use priorities.

U.S. Mineral Potential

The United States is large and geographically varied enough to possess commercial quantities of most important minerals. Every state has active mines and significant quantities of up to 40 different mineral commodities. Minerals-rich areas are widely scattered, reflecting the diversity of the natural forces that produced them. In 1988, the list of states leading in the production of at least one of 58 mineral commodities included California (portland cement), Oklahoma (gypsum), Missouri (lead), Idaho (garnet and vanadium), Arizona (copper), Montana (platinum and talc), Nevada (gold and silver), Florida (phosphate), Alaska (petroleum), Texas (natural gas), Wyoming (coal), Minnesota (iron ore), and 13 other states.

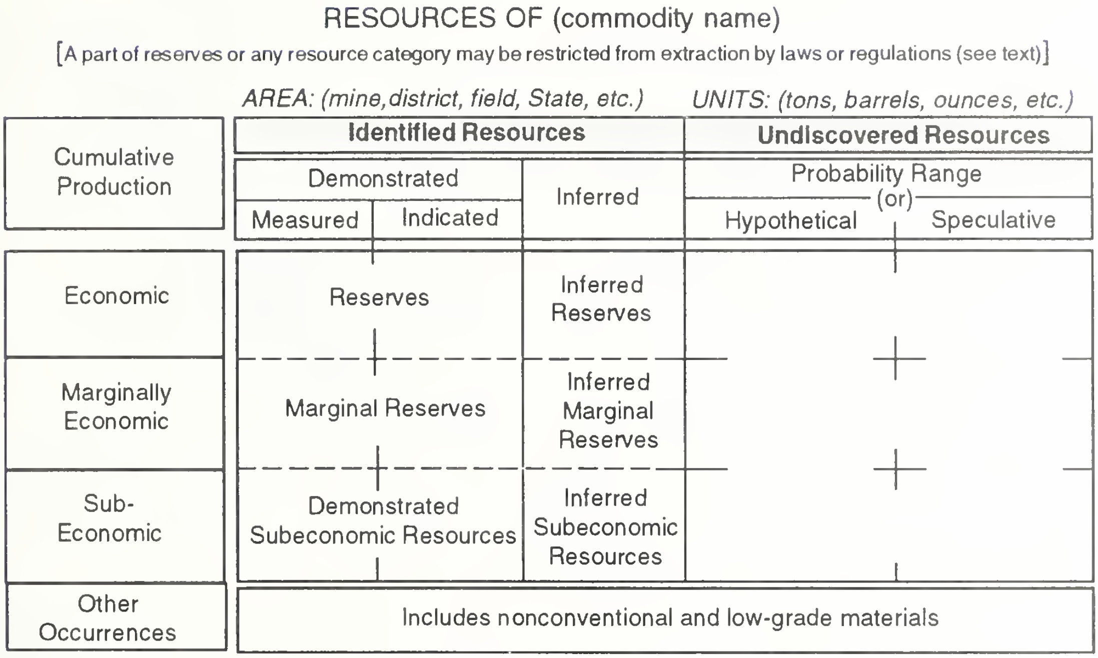
Figure 1-3 identifies the metallic mineral areas of the U.S. Figure 1-1 displays coal fields. Additional maps would be needed to identify deposits of petroleum, natural gas, and various industrial minerals. The Northern Region States of Idaho, Montana and the Dakotas are among the leading producers of copper, lead, silver, gold, vanadium, platinum (and related metals), zinc, antimony, garnet, phosphate, bentonite, talc, lime, salt, clays, sand and gravel, building and decorative stone, oil, coal, and natural gas.

The U.S. Bureau of Mines makes periodic estimates of the mineral resources and reserves of the U.S. and world and forecasts future demand patterns. From these, we observe that individual minerals vary widely in their abundance. Six examples are provided in Table 1-3.

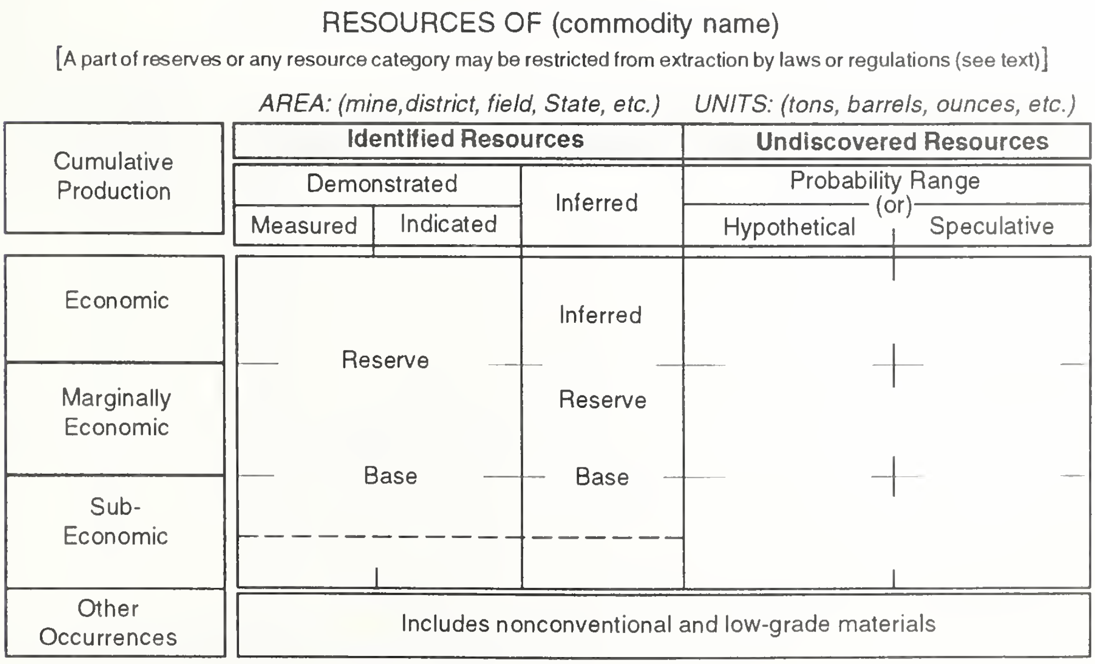
Note that the expected U.S. demand for bauxite (aluminum ore) greatly exceeds domestic reserves, but world reserves are over 10 times the predicted world demand for the 1983-2000 period. The U.S. will be dependent on imports or substitutes, unless new domestic reserves are discovered. In the case of platinum, the situation has improved since the Table 1-3 estimates were made. Some platinum resources of the Custer and Gallatin National Forests in Montana have

[6/] After definitions standardized by the U.S. Geological Survey and Bureau of Mines.

Figure 1-2 **Classifying Mineral Resources**



Major elements of mineral-resource classification, excluding *reserve base* and *inferred reserve base*.



Reserve base and *inferred reserve base* classification categories.

Figure 1-3 **Mineralized Areas of the United States**

Locations Favorable to Metallic Ore Deposits

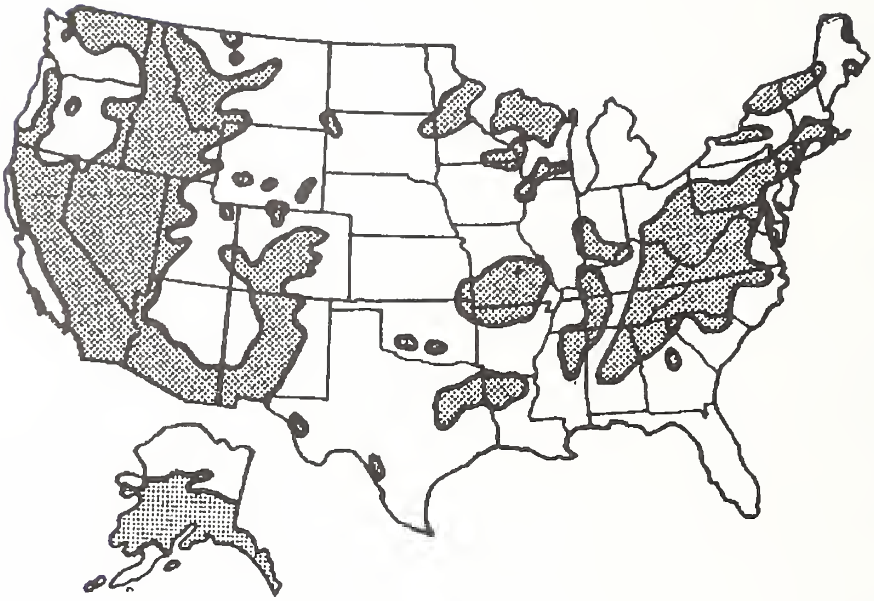


Table 1-3
U.S. and World Reserves and Cumulative Primary Demand for Selected Commodities

Commodity	Unit	Cumulative Primary Demand, 1983-2000 U.S.	Cumulative Primary Demand, 1983-2000 World	Reserves U.S.	Reserves World	Ratio of U.S. Reserves to U.S. Cumulative Primary Demand
Bauxite	million metric tons, aluminum metal equivalent	101	395	8	4,420	0.08
Copper	million metric tons	31	168	57	340	1.84
Iron Ore	million metric tons, iron content	816	8,981	3,357	65,318	4.11
Phosphate	million metric tons	700	3,200	1,400	14,000	2.00
Platinum Group	million troy ounces	34	130	1	1,000	0.03
Tungsten	thousand metric tons, tungsten content	226	967	150	2,800	0.66

Source: U.S. Dept. of the Interior, Bureau of Mines, Mineral Facts and Problems, 1985.

been reevaluated as reserves, a new mine is now operational, and an additional mine is in the planning stages.

It is reasonable to expect some upward revision of estimated resources and reserves due to continuing exploration for new deposits. In addition, the development of new mining technologies that permit utilization of lower-grade ores will justify the conversion of some resources to reserves.

SUPPLY AND DEMAND FOR MINERALS

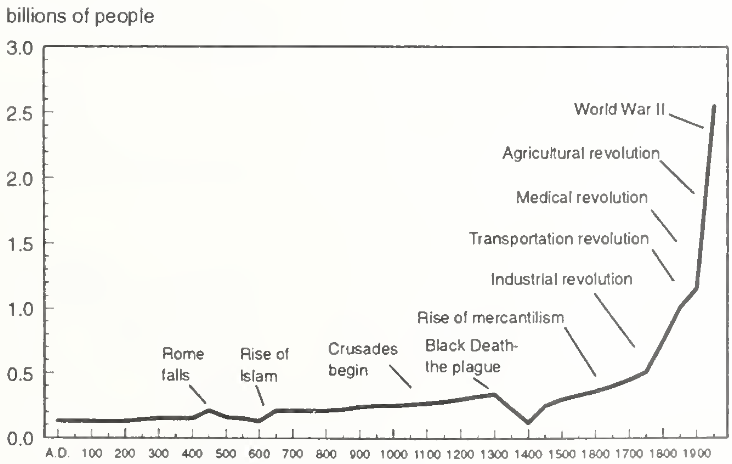
The total world demand for minerals and mineral fuels has steadily increased for decades and exceeded $1.8 trillion in 1990.[7] In the U.S., total consumption of mineral materials increased about 3.8 percent annually from 1950 to 1970.[8] Then it gradually leveled off in response to increased energy costs, economic recessions, the substitution of plastics for metals, increased recycling, and other factors.

Expanding World Demand

From 1750 to 1900, the world's demand for minerals increased about tenfold while population only doubled (Figure 1-4). After that, both population and world minerals demand increased much faster. Between 1950 and 1975, the world demand for minerals and mineral fuels increased between 50 and 75 percent each decade, more rapidly than in the U.S. (Figures 1-5 and 1-6). One important factor has been world population

Figure 1-4

World Population Growth, 1 A.D. to 1950



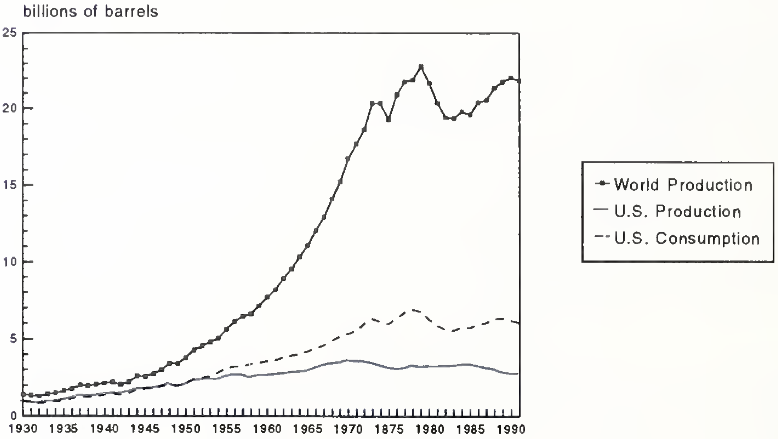
Source: Lamm, Richard D., et al., Hard Choices, Center for Public Policy and Contemporary Issues, University of Denver, 1989, p. 36.

[7] U.S. Dept. of the Interior, Bureau of Mines, Mineral Commodity Summaries, 1991.

[8] Based on median rate of increase reported for 87 metals, nonmetal minerals, and gases by the Bureau of Mines in Minerals Trends and Forecasts, 1979.

Figure 1-5

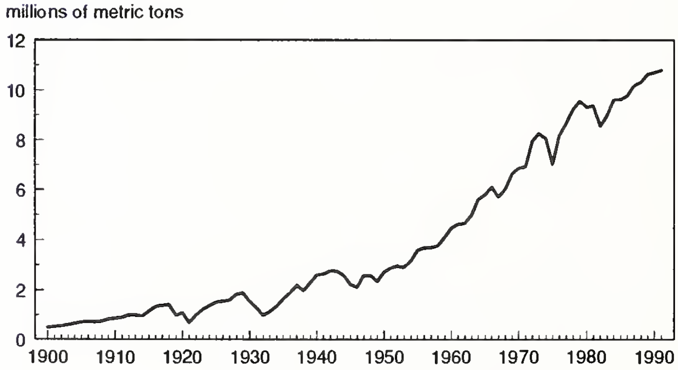
World Production and U.S. Production and Consumption of Crude Petroleum



Source: U.S. Dept. of Energy, Energy Information Administration, Annual Energy Review 1991, June 1992, and U.S. Dept. of Interior, Bureau of Mines, Mineral Facts and Problems and Minerals Yearbook, various years.

Figure 1-6

World Copper Consumption, 1900 to 1991



Source: Jolly, Janice, U.S. Department of Interior, Bureau of Mines, personal communication, September 11, 1992.

growth, which averaged almost 2 percent annually during this period. Between 1950 and 1990, the world's population doubled and continued growth at this rate would again double the world's population in about 40 years. Several "developing" nations now double their populations in as few as 20 to 25 years, while most established industrial nations require at least 75 years to double in size.[9/] During the 1980s, a few European nations achieved zero population growth through voluntary reduction of family size, but most countries continue to grow steadily, and growth alone implies consumption of a greater volume of natural resources each generation.

Rapid modernization is a second reason for sharp increases in world minerals consumption. Extensive reconstruction occurred in Europe, the U.S.S.R., and Japan following the widespread devastation of World War II. At the same time, dozens of Asian, Mideastern, African, and Latin American nations launched programs of industrialization. Additional mineral deposits were developed, new industries were established, and extensive urbanization followed with its associated construction activities. In 1990 an estimated 20 billion tons of sand, gravel, and building stone were mined in the world, principally for use in construction. A half billion tons of both iron and clay were also produced.

In the industrial democracies of the West, a rising material living standard has been a major factor contributing to increased minerals consumption. Recent population growth has been relatively slow (0 to 1 percent annually in most countries), and capital investment in new plants and equipment has gradually stabilized. Yet for several decades, per capita consumption of many vital commodities has continued to increase because families and individuals redefine their needs at ever-higher levels. Consumer expectations rise, in part, because of an expanding and increasingly effective advertising industry. One result has been a drain on the mineral reserves of many countries. Japan and, to some extent, western European nations with rising levels of consumption must now import a larger share of raw materials from Third World countries.

Compared to a generation ago, the contemporary citizen demands and receives more automobiles, home conveniences, living space, electronic equipment, toys, clothing, fast foods, commercial recreation, health care, schooling, and other consumer goods and services that require minerals in their manufacture, packaging, or performance. These goods are viewed as desirable, useful, and in many cases, necessary. Many people regard them as evidence of career success and high status. Table 1-4 provides several examples of U.S. consumption increases in recent years.

The expectation of continuing economic growth and increased consumption of factory goods and professional services is shared by the growing middle and industrial working classes of the world's developing nations. Universal achievement of this goal would require the commitment of several times more mineral resources each generation than are now consumed, unless there are compensating trends such as reduced population growth rates, greater energy efficiency, longer product life, or recycling of discarded materials.

A scarcity of mineral resources worldwide is not the most immediate threat to future generations. Of greater concern are the environmental impacts of ever-expanding production of virgin

[9/] U.S. Dept. of Commerce, Bureau of the Census. Current Population Reports.

Table 1-4 U.S. Per Capita Consumption Increases			
CATEGORY	EXAMPLES	CURRENT LEVEL	EARLIER LEVEL
Housing Units	Median number of rooms per unit	5.2 in 1987	4.9 in 1960
	Percent with air conditioning (room or central)	63.7 in 1987	15.1 in 1960
	Percent with television sets	98.2 in 1990	9.0 in 1950
	Percent with clothes dryers	65.8 in 1987	19.6 in 1960
	Percent with microwave ovens	60.8 in 1987	(not available)
	Percent lacking some or all plumbing	2.7 in 1980	13.2 in 1960
Energy	Millions of BTUs consumed per capita	325 in 1990	233 in 1950
Water	Water demand, gallons per capita daily	1,400 in 1985	1,027 in 1940
Transportation	No. registered vehicles, per person	.76 in 1989	.41 in 1960
	Passenger miles flown (billions)	347 in 1989	31 in 1960
Social Services	Health Expenditures: percent of GNP	11.6 in 1989	4.4 in 1950
Waste Disposal	Pounds of solid waste generated per person per day	4.00 in 1988	2.66 in 1960
	Waste recovered per person daily	.52 in 1988	.18 in 1960
Education	Median years of school completed	12.7 in 1989	10.6 in 1960
	School expenditures: percent of GNP	6.8 in 1989	3.3 in 1950

Source: Statistical Abstract of the U.S., 1979, 1982-1983, 1991.

resources. The minerals policies of many countries encourage tapping new resources more than conserving and recycling existing supplies. Mining and manufacturing, and intensified agriculture as well, imply increased pollution of air, water, and soil. This can have serious consequences for human health, natural ecosystems, and possibly climatic change if environmental protection strategies are ignored or are ineffective (Chapter 3).

The adoption of new technology and the simultaneous development of remaining rich deposits of known mineral reserves in the Third World keeps mineral prices relatively low. Some countries depend heavily on their mineral exports for jobs, tax revenues, and "hard" currencies to purchase needed imports. Their domestic need for minerals is still limited by their degree of industrialization. The low prices they receive for their exports do not accurately reflect external costs of producing minerals, such as air and water pollution, and impacts on their traditional lifestyles, wildlife, and vegetation.

Domestic Requirements

For some decades, the United States and Canada have led the world in per capita consumption of most categories of mineral commodities, including energy, metals, industrial minerals, and factory goods. Energy demand serves as a rough indicator of the demand for most of the other minerals. The U.S., with less than 5 percent of the world's people, uses about 21 percent of the available commercial energy. To illustrate the magnitude of this level of demand, if all of the people on earth used energy at the per capita rate

of the U.S., over four times as much commercial energy would be consumed each year[10] (Figure 1-7).

In the U.S., about 36 percent of commercial energy is consumed in heating, 27 percent goes for transportation, industry consumes 34 percent, and agriculture uses 3 or 4 percent.[11] The mining and minerals processing industries are major industrial energy consumers.

Rising consumption implies increased family "buying power" and requires expanded supplies of raw materials. Both trends were very evident in the U.S. between 1950 and 1973, when median family income increased from $16,315 to $33,656 (in constant 1989 dollars), a rise of over 100 percent.[12] Some factors that have contributed to increased buying power are:

- a dramatic increase in the number of wives employed outside of the home (from 25 percent in 1950 to 58 percent in 1989),

- increased industrial efficiency, permitting negotiated and legislated wage increases,

- extended credit arrangements, enabling consumers to commit future income,

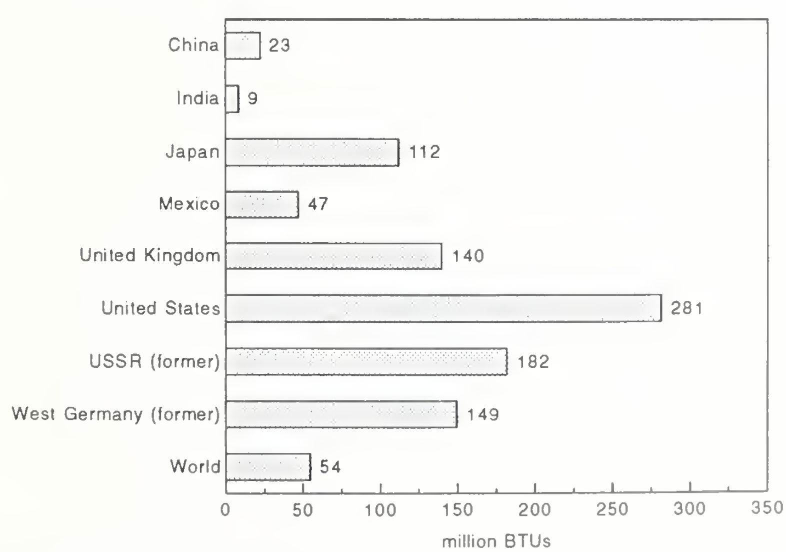
- the discovery and development of rich overseas deposits of oil and essential metals, offered at still-competitive prices,

- market competition offered by Japan and European Community nations, tending to hold down prices of manufactured goods, and

- increases in social programs that supplement and stabilize family incomes.

Figure 1-7

1989 Per Capita Commercial Energy Consumption in Selected Nations



Source: United Nations, Department of International Economic and Social Affairs, 1989 Energy Statistics Yearbook, Table 1, 1991.

[10] Statistical Abstract of the United States, 1991.

[11] U.S. Dept. of Energy, Monthly Energy Review, August 1991.

[12] Statistical Abstract of the United States, 1984, 1991.

The expansion of family buying power began to level off in 1974 with the sharp escalation of energy prices and gradually stabilized, reaching $34,000 in 1989.

Import-Export Trends

Although some energy is used to produce commodities for export, this is offset by the fact that even more raw materials and manufactured products are imported. In 1989 the value of U.S. imports exceeded exports by 35 percent.[13/] When fuels are omitted from this computation, exports exceed imports by 24 percent. In the automotive, appliance, electronic, and optical industries, imports were almost double exports. In agriculture, the U.S. imported about 55 percent of the volume it exported. Table 1-5 shows the U.S.-to-world production relationship for important mineral commodities.

For most commodities, domestic production has steadily increased since 1950, responding to the needs of an expanding population with a rising living standard. In 1991, about 25 percent of 46 key nonfuel minerals monitored by the U.S. Bureau of Mines were amply produced in the U.S.[14/] The remainder were partially imported, including 25 percent that were almost totally imported. Of these minerals, the median amount imported was about 68 percent of total demand. Figure 1-8 provides details.

The percentage of a given commodity imported, less the amount exported, plus any adjustments due to reallocation of supplies on hand, is the "net import reliance." The U.S. import reliance for most minerals remained stable or has increased gradually.[15/] In contrast, our reliance on imported crude oil has increased dramatically during this period. Until the 1950s, the U.S. was the major world producer and an important exporter of oil. This changed when high-volume fields were developed in Venezuela, the Middle East, and elsewhere. By 1977 the U.S. was importing 47 percent of its oil at $13.34 per barrel compared to $3.18 per barrel in 1970.[16/] This declined to 40 percent in 1981, when the average import price exceeded the $30 mark (Figure 1-9 shows this trend). Federal decontrol of oil prices in

Table 1-5
U.S. Mineral Production as a Percentage of 1990 World Mine Production

Aluminum	23	Gold	14	Oil, crude	12
Asbestos	1	Gypsum	15	Phosphate	30
Bauxite Ore	1	Iron Ore	6	Salt	20
Cement	6	Lead	15	Silver	14
Coal	18	Molybdenum	55	Sulfur	20
Copper	18	Natural Gas	24	Zinc	7

Source: U.S. Bureau of Mines, Mineral Commodity Summaries 1992, 1992

13/ Statistical Abstract of the United States, 1991

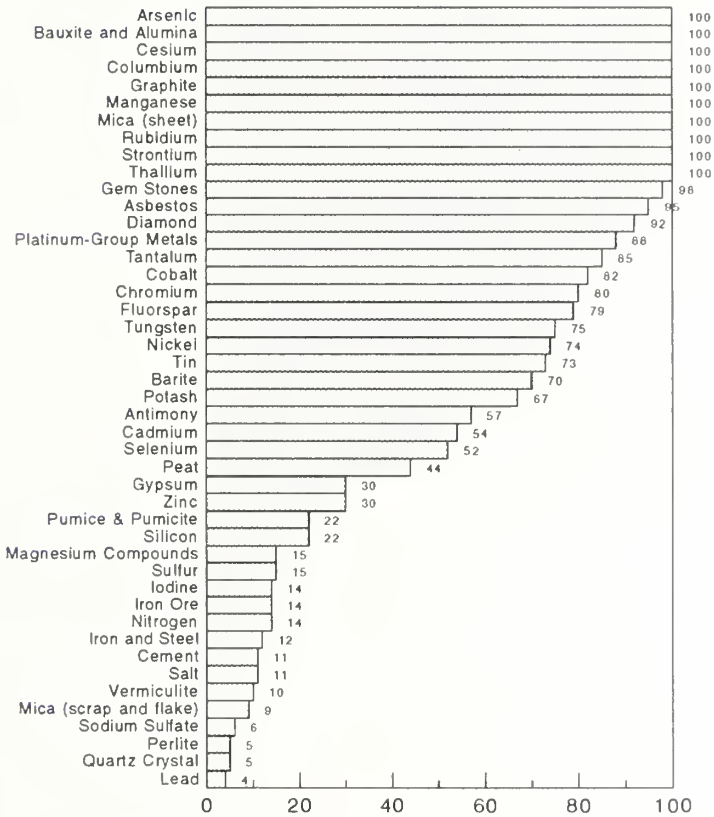
14/ Mineral Commodity Summaries, 1992.

15/ See U.S. Dept. of the Interior, Bureau of Mines publications for details (Footnote 2).

16/ U.S. Dept. of Energy, Monthly Energy Review, 1981 and earlier.

Figure 1-8

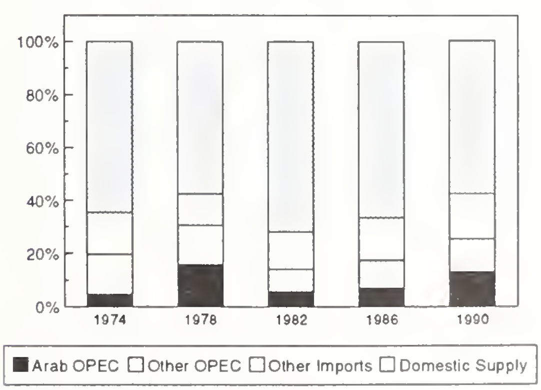
1991 Net Import Reliance of Selected Nonfuel Mineral Materials as a Percent of Apparent Consumption



Source: U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries 1992, p.3.

Figure 1-9

U.S. Dependence on Petroleum Net Imports



Source: U.S. Department of Energy, Monthly Energy Review, August 1991

1981 allowed the price of domestic oil to rise to comparable levels and encouraged further exploration and development in this country.

Initially, the drastic price increase of crude oil forced corresponding increases in the cost of gasoline, fuel oil, and other petroleum products. This in turn encouraged consumers to conserve energy in a variety of ways. The federal government set fuel economy standards for automobiles and offered tax incentives for insulating older homes. U.S. passenger cars were downsized from an average of 4059 pounds in 1976 to 3101 in 1980 (but again eased upward to to 3116 pounds in 1989 after several years of cheap and abundant gasoline).[17/] Table 1-6 shows how downsizing cars and improving engine efficiency reduced fuel consumption. Industries shifted to more energy-efficient equipment, and energy conservation measures were adopted in many homes and offices. Many cities extended and improved their mass transit systems and encouraged car pooling to conserve energy, to reduce traffic congestion, and to curb pollution. Meanwhile coal demand has increased, but oil and gas are still the preferred fuels because they are more convenient to use and emit less objectionable pollutants. Figure 1-10 compares the sources of energy consumed in the U.S.

Since 1985, when OPEC members were unable to maintain a uniformly high price for their exported crude oil, the price usually has hovered between $12 and $16 per barrel, about half of the 1981 figure. This sharp decline in energy prices and the news of a "glut of oil" on the market undermined the country's determination to conserve energy and U.S. consumption again rose. An equivalent increase in demand did not occur in Europe due to high fuel taxes which make gasoline two to three times more expensive than in the U.S. A portion of the higher level of energy consumption is attributed to generally hotter summers, colder winters, and longer commutes to work. However, most of the difference stems from American lifestyles and values. For example, compared to western Europe, more people use private autos instead of mass transit, and the much lower gasoline prices encourage this. Fewer people walk or ride bicycles to work, school, errands, and recreation. Teenagers own and heavily use cars, more families live in one-family homes, homes and offices are more frequently overheated in winter and supercooled in

Table 1-6
Average Passenger Car Efficiency

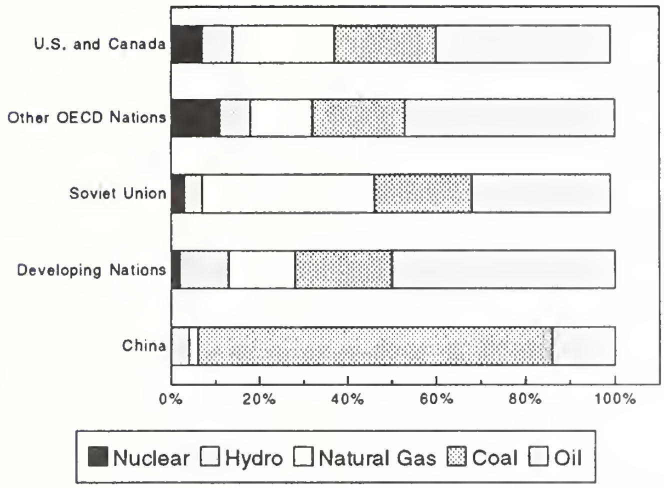
Year	Miles Per Gallon	Year	Miles Per Gallon
1973	13.3	1983	17.1
1975	13.5	1985	18.2
1977	13.8	1987	19.2
1979	14.4	1989	20.3
1981	15.9	1990	20.9

Source: U.S. Dept. of Energy, Energy Information Administration, Annual Energy Review 1991, June 1992

17/ Kramer, D.A. and P.A. Plunkert. "Lightweight Materials for New Cars", in Minerals Today, August 1991.

Figure 1-10

Primary Energy Consumption by Source, 1988



Source: British Petroleum, BP Statistical Review of World Energy, 1989, (London, 1989), p. 34.

summer, and lights and appliances are more often left on when not in use. Table 1-7 compares U.S. and Canadian petroleum consumption with other industrial nations.

There are many reasons why a free-market country such as the U.S. may import some of its minerals. Most obvious is that some minerals may not occur in significant amounts in the U.S. or they are cheaper overseas because of inequities in the currency exchange rate, efficiency of overseas production facilities, or other factors. In addition, many U.S. mining corporations have extended their operations abroad when (1) mineral deposits are very rich, (2) pollution controls are less rigid, (3) labor is less expensive, and/or (4) expanding consumer markets exist.

Table 1-7
Petroleum Consumption in Major Organization for Economic Cooperation and Development (OECD) Nations

	Millions of Barrels Daily				Barrels Annually per capita	
	1974	1980	1985	1990	1980	1990
Canada	1.78	1.87	1.50	1.70	28.4	23.8
France	2.45	2.26	1.77	1.81	15.3	11.9
Italy	2.00	1.93	1.72	1.84	12.6	12.0
Japan	4.86	4.96	4.38	5.22	15.5	15.5
U.K.	2.21	1.73	1.63	1.75	11.2	11.3
U.S.A.	16.65	17.06	15.73	16.99	27.4	24.9
W. Germ	2.75	2.71	2.34	2.38	16.0	14.3

Source: U.S. Dept. of Energy, Energy Information Administration, Annual Energy Review 1991, June 1992

The U.S. has increasingly close economic ties with the rest of the world, both as a supplier of factory and farm products and as a customer for both raw materials and finished goods. Tariffs have been reduced worldwide and more countries now participate in world trade. Since 1950, international transportation and communications networks have been extended and international trade has increased over 40 times in current dollar value to almost $3 trillion dollars in 1990.[18] The U.S. Bureau of Mines reports that the role of multinational mining corporations has greatly expanded in recent years. Mineral corporations in 18 industrial nations operate at least 276 mines and 113 smelters and refineries in some 57 foreign countries and provide a growing share of the world's mineral products.[19]

In 1990 the U.S. imported $495 billion worth of commodities and exported goods valued at $394 billion. That year petroleum imports cost the U.S. $53 billion, and $44 billion was spent for a wide variety of raw and processed mineral materials. Thus mineral imports of $97 billion, compared to minerals exports of about $38 billion, created a $59 billion deficit in this trade category, mostly due to crude oil purchases.

Looking Ahead

Perceptions of future resource availability vary considerably, depending in part on underlying assumptions. Optimistic industrialists, mining engineers, geologists, and economists point out that the earth's crust is composed of minerals and that seawater is saturated with them. In this view, the assurance of future supplies is contingent on having proper incentives, opportunities, and mineral technologies, which are regarded as possible and foreseeable.

More cautious scientists and environmentalists express concern about the future energy and minerals situation (see Bibliography). In the past 100 years, accelerated population growth (world population has doubled since 1950 and almost quadrupled since 1890) and rising per capita consumption have greatly increased the demand for minerals and other natural resources. At the same time, the lands open to mineral development have been reduced due to business and residential expansion, establishment of public and private preserves and special-use areas, and so many other needs. In addition, many areas already have unacceptable levels of pollution from existing industries, abandoned industrial sites, commercial and residential areas, and traffic.

Although U.S. per capita consumption of newly-mined mineral products doubled for several decades, indications are that this trend has leveled off. Some observers predict per capita consumption will eventually turn downward as rising energy prices, continuing population growth, and Third World industrial development make additional demands on the finite natural resources of the world. Higher oil prices are regarded as only the first of a series of price increases spurred by diminished resource supplies or price fixing agreements among major suppliers. This "day of reckoning" is being delayed by tapping and importing the resources of developing nations that still use limited quantities domestically but seek "hard" foreign currencies through trade.[20]

Scientists in many fields seriously question the feasibility of perennial world economic growth for two basic reasons: (1) the eventual shortages of various critical resources in economic concentrations, and (2) the limited capacity of the

[18] Statistical Abstract of the United States, 1991.

[19] U.S. Dept. of the Interior, Bureau of Mines. Research 91, 1991, p. 34.

[20] Young, John E. "Mining the Earth", in Lester R. Brown, Ed., State of the World. New York: W.W. Norton, 1992.

environment to withstand more pollution, ecosystem destruction, and other impacts associated with their extraction and processing. It is essential to consider the health and well-being of this generation, future generations, and other nations that may be adversely affected by continuing rapid growth. Chapter 3 examines this dilemma in greater detail.

Local and sometimes regional natural resource depletion and pollution are age-old problems. Many people in past generations often resolved them by migrating to a more favorable environment and natural processes sometimes healed the wounds they left behind. But this is no longer a viable solution when all parts of the world are populated, migration is increasingly restricted, and environmental concerns are global in scope.

As the world's richest and most accessible ore deposits are depleted and additional low-grade sources are developed, the cost of production is likely to increase. The mounting cost of domestic petroleum production is a good current example. The resulting rise in the price of mineral commodities will affect production and consumption patterns. Producers will experiment with newer minerals technologies and seek additional sources; e.g., other metal-bearing ores that were previously uneconomic to process. The scrap metal industry will expand and more metals and other valuable minerals will be recycled. Efforts to design products that require less raw materials and consume less energy (e.g., autos, appliances, and electronic equipment) will intensify.

For agency planners this means increasing resource conflicts as competing interests look to the public lands for business and residential space, municipal water sources, waste disposal sites, recreation facilities, preservation of old-growth forests and natural areas, pastures for livestock, road and energy corridors, and sites for mines and surface facilities.

Despite these concerns, considerable investment in mining operations is occurring, both in the U.S. and overseas. The Engineering and Mining Journal identified 296 projects being planned or constructed in 1991, at a projected cost of over $55 billion.[21] A large portion of the investment in mines and metals processing operations is outside of the U.S., as Table 1-8 indicates.

The potentials of seawater (which covers 70 percent of the earth's surface and contains numerous dissolved minerals), undersea mining (principally on continental shelves), and ocean-floor nodule mining are being explored. Currently, salt, bromine, and magnesium, all relatively abundant seawater components, may be extracted, but dozens of other valuable mineral substances are also present. Although some minerals (e.g., gold, chromium, and tungsten) are too dilute to be extracted economically with existing technology, new processes could change this.

The world's continental shelves overlay mineral deposits that are now being tapped in shallow locations. As new mining techniques are perfected, mineral resources may be extracted at greater depths. Techniques are being devised for gathering manganese nodules from the sea floor. These nodules contain assorted metallic elements including manganese, iron, nickel, copper, barium, aluminum, and cobalt.

[21] "Mining Investment 1991", in Engineering and Mining Journal, January 1991.

Table 1-8
Projected Capital Investment for Metals Projects in the 1990's
(Aluminum, copper, lead, zinc, iron ore, nickel, gold, and uranium)

	No. of Projects	Billions of Dollars	Percent
North and Central America	100	11.5	21
South America & Caribbean	55	13.8	25
Europe	18	2.0	4
Africa	42	8.4	15
Japan and Asia	47	12.1	22
Australia and Oceania	34	7.3	13
TOTAL	296	55.2	100

Source: Engineering and Mining Journal, January 1991

As mineral prices rise, consumers will more often select either cheaper mineral substitutes or products made from plastics, wood, wood wastes, crop residues, or other substances. For more than a decade, the increase in the volume of plastics produced in the U.S. has outpaced copper, steel, and aluminum.[22/] However, for many existing uses, minerals are presently preferable or irreplaceable. Some consumers will either be unable to afford them or will have to settle for a smaller quantity.

The rising cost of locating and extracting crude oil stimulated oil shale development research in Colorado and other Rocky Mountain states. The Colony Project in Colorado was designed to produce 50,000 barrels of shale oil daily for 30 years.[23/] This was about 0.3 percent of U.S. consumption in 1980. In 1980 Exxon unveiled a scenario for a $500 billion oil shale industry based in Colorado.[24/] Both projects were abandoned when world oil prices fell drastically in the early 1980s. Renewed world economic growth could cause a surge in oil prices that could again make oil shale development economically attractive.

Coal is another potential source of both synthetic gas (methane) and gasoline. Huge coal fields (Figure 1-1) exist on the Great Plains and in the intermountain basins of the West. Portions of these fields are now being developed in several states, including Montana, North Dakota, Wyoming, Colorado, Utah, and Arizona. Plant construction and the extraction and conversion of oil shale and coal require substantial work forces and large quantities of energy. An increase in U.S. coal consumption is projected for the remainder of this century, with western states supplying 49 percent of the total in the year 2000,

[22/] Rogich, Donald G. "The Future of Minerals: Plastic Component is Growing", in Minerals Today, June 1991, pp. 30-32.

[23/] "Colony Project and Battlement Mesa Development", in The Mining Record, October 28, 1981, p. 4. Construction was suspended in May 1982 and attributed to the 1981-1982 decline in oil prices (Mining Record, May 5, 1982).

[24/] Engineering and Mining Journal, July 1980, p. 47.

compared to 29 percent in 1980.[25] Industry and utilities will consume most of the increased production.

MINERALS MANAGEMENT IN THE NORTHERN REGION

Many land areas remain in public domain because their rough terrain and high elevation are unsuited to agriculture. Much of this acreage is now managed as National Forests, parks, monuments, and wildlife refuges. Many of these lands contain large, relatively undeveloped mineralized zones.

The Region's Mineral Resources

In the Forest Service's Northern Region, commercial quantities of copper, lead, zinc, silver, gold, platinum, chromium, nickel, molybdenum, manganese and other metals are known to exist. There are also important deposits of phosphate, talc, limestone, coal, decorative stone, gems and other industrial minerals and fuels useful in industry and agriculture.

Some idea of the ultimate minerals potential of the Northern Region can be gained from a study conducted by the Region's geologists and mineral economists. In the Lolo Forest alone, there are 234 mineral deposits. There are at least five occurrences each of gold, silver, lead, copper, zinc, antimony, arsenic, barite, and fluorspar. Tungsten, kaolin, pumice, iron, uranium, germanium, nickel, cobalt, and molybdenum are also known to exist. To this list could be added sand and gravel, dimension stone, decorative stone, and gemstones (Table 1-9).

In 1979 only about 4 percent of the value of minerals production in Montana, Idaho, and the Dakotas occurred on National Forest System lands. In 1982 an estimated 15-20 percent of production was from National Forest claims and leases. This great increase was mainly due to the oil and gas activity in the National Grasslands of western North Dakota and several new mines in western Montana.

Most National Forest System lands (excluding most wildernesses, which were closed to mineral entry in 1984) are open to mineral claims or mineral leasing. The miner's rights are defined by a series of laws and vary according to the type of mineral sought and the legal status of the land (whether public domain or subsequently acquired federal lands).

Federally-owned minerals on Forest lands are placed in three general categories denoting the procedure for acquiring authorization to extract minerals from them. These are locatable, leasable, and salable, each described below.

Locatable. Regulated by the General Mining Law of 1872 (17 Stat. 91, as amended; 30 U.S.C. 22 et seq.). This category includes intrinsically valuable minerals such as gold, silver, and platinum, and other metallic minerals; e.g., copper, lead, zinc, cinnabar (mercury ore), iron, tungsten, molybdenum, etc. Some industrial minerals such as high quality gypsum or feldspar, or metallurgical or chemical grade silica and limestone are also included.

U.S. citizens and domestic firms are permitted to explore for minerals on most National Forest System lands, provided they observe Forest Service rules and regulations. If a valuable deposit is discovered, the finder has the right to locate a claim and to mine and market the mineral.

[25] For estimates, see: The Mining Record, April 29, 1981, p.2; June 17, 1981, p. 19.

Table 1-9
The Minerals Situation in the U.S. and Northern Region - 1991

Mineral (or ore)*		Extent of Imports**	Regional Situation***		Mineral (or ore)*		Extent of Imports**	Regional Situation	
			States	Forests				States	Forests
Aluminum metal		0	P		Magnesium		0		
Antimony	C	XX	EP	EP	Manganese	C	XXX	E	E
Arsenic		XXX	E	E	Mercury	C	NA		
Asbestos	C	XXX	E		Mica (scrap)		0	E	
Barite		XX	EP	EP	Mica (sheet)	C	XXX	E	E
Bauxite	C	XXX			Molybdenum		0	EP	E
Bentonite	C	0	EP		Nickel	C	XX	E	E
Bismuth	C	XXX	E		Nitrogen (ammonia)		0		
Boron	C	0			Oil shale, sands		0	E	
Cadmium	C	XX	E		Peat		X	E	
Cement		0	EP		Perlite		0	EP	
Cesium	C	XXX			Petroleum	C	X	EP	EP
Chromium	C	XXX	E	E	Phosphate	C	0	EP	EP
Clays		0	EP		Platinum Group	C	XXX	EP	EP
Coal		0	EP	EP	Potash	C	XX	E	
Cobalt	C	XXX	E		Quartz Crystal		0		
Columbium	C	XXX	E	E	Rubidium ore	C	XXX		
Copper	C	0	EP	EP	Rutile	C	NA		
Corundum		XXX	E	E	Salt		0	EP	
Dimensional Stone		NA	EP	EP	Sand & Gravel		0	EP	EP
Diamonds	C	XXX			Selenium	C	XX		
Feldspar		0	EP		Silicon		X	E	E
Fluorspar	C	XXX	E	E	Silver	C	NA	EP	EP
Garnet		0	EP	EP	Sodium compounds		0		
Germanium	C	NA			Strontium	C	XXX		
Gold	C	NA	EP	EP	Sulfur	C	0	EP	
Graphite, natural		XXX	E		Talc		0	EP	EP
Gypsum		X	EP		Tantalum	C	XXX	E	E
Helium		0			Tellurium	C	NA		
Ilmenite	C	NA	E	E	Thorium	C	NA	E	E
Indium	C	NA			Tin	C	XX	E	
Iodine		0			Titanium metal	C	0	E	E
Iron ore	C	0	EP	E	Tungsten	C	XX	E	E
Kyanite		0	E	E	Uranium	C	X	EP	E
Lead	C	0	EP	EP	Vanadium	C	NA	EP	
Lime		0	EP		Vermiculite		0	EP	EP
Lithium	C	0			Zinc	C	X	EP	E
					Zirconium	C	0	E	E

*C = Defined as "of compelling domestic significance" by the U.S. Geological Survey and the U.S. Bureau of Mines in a 1978 memo.

**Import dependency, as of 1991, is as follows:
XXX = 80 percent or more of domestic consumption is imported
XX = 50 percent to 79 percent is imported
X = 20 percent to 49 percent is imported
0 = Net exporter or less than 20 percent is imported
NA = Insufficient data to estimate imports

***Northern Region mineral activities summarized
E = The mineral is known to exist or being actively sought in one or more Northern Region states (or Forests).
P = Production is scheduled or occurring in one or more Northern Region states (or Forests).

The Federal Land Policy and Management Act (FLPMA) and the laws of individual states regulate monumenting (staking) and recording of claims. The claimant is also entitled to reasonable access to his claim and permitted to use as much of the claim surface and its resources (timber, stone) as reasonably necessary to extract the mineral or ore. Claims must be registered at the appropriate Bureau of Land Management Office. The claimant must also present evidence to that office of at least $100 of labor or assessment work contributing to the development of the discovery by December 30 of each year, if the claim is to remain valid.

There are modest fees for locating claims; i.e., a $10 filing fee, plus minor costs relating to the required paperwork. There are no rentals or royalties to pay for locatable minerals removed from public domain lands.[26/] The historic purpose behind this "gift" to the miner is to promote the discovery and development of the nation's mineral wealth.[27/]

Claims are of two basic types: lodes and placers. Lode claims are for veins or lodes in place and have maximum dimensions of 600 x 1500 feet, with the 1500-foot dimension laid out along the trace of the vein or lode on the surface. Placer claims are for secondary deposits such as alluvial gold deposits. The size of placer claims varies according to the number of locators. One locator may claim 20 acres, two may claim 40, and so on up to 8 locators who may claim a maximum of 160 acres per claim.

Two other types of claims are for millsites and tunnel sites. Millsites are additional nonmineralized land used for a mill or some other nonextractive purpose related to mining. Such uses may be an office, shop, waste dump, etc. Millsites are a maximum of five acres in size. A tunnel site is not a mining claim in the true sense of the word; it is an exclusive right to prospect and, subsequently, a possessory right to lay claim to any "blind" lode, vein, or ledge within a 3000 foot square area containing a valuable mineral deposit that has been discovered by driving the tunnel.

The Multiple Use Mining Law of 1955 (69 Stat. 367, 30 U.S.C. 601, 603, 611-615) provides that (unpatented) mining claims shall be used only for prospecting, mining, minerals processing operations, and clearly related activities. The federal government has the right to remove plant materials or to manage other surface resources as long as the claimant's mining activities are not unreasonably obstructed.

If a discovery of a valuable mineral deposit is made and certain other conditions are met (i.e., $500 worth of work on the claim and application requirements), a patent (legal title to the claim) may be granted. Federal court decisions have established that mineral deposits must be economically valuable to be patented. That is, a "prudent man"[28/] would find it worth his time and investment to extract the mineral.

Patent application is made to the State Director of the Bureau of Land Management. The claim is surveyed (requiring the services of a professional surveyor) and the economic worth of its mineral deposit is evaluated. If a patent is granted, a fee is assessed and the claim is thereafter regarded as private property.

Leasable. More recent legislation has provided for leasing certain categories of minerals with the

[26/] For a comprehensive discussion of mining law, see: Pruitt, Robert G., Jr., Digest of Mining Claim Laws. Boulder, CO, Rocky Mountain Mineral Law Foundation, 1977.

[27/] A discussion of the "free minerals" issue and attempts to modify this legislation is found in: U.S. Council on Environmental Quality, Hard Rock Mining on Public Land, 1977, pp. 10-21.

[28/] "... where mineral is found and the evidence shows that a person of ordinary prudence would be justified in the further expenditure of his labor and means, with a reasonable prospect of success in developing a valuable mine." (Castle vs. Wamble, December 5, 1984)

government retaining title to the land and collecting annual rentals and royalties on minerals extracted. Leasing is also the procedure for gaining access to all minerals on federal lands that have been acquired since 1897 through purchase, gift, or other transactions (about 8 percent of the total). Leasing is authorized by the Minerals Leasing Act of 1920 (41 Stat. 437, as amended; 30 U.S.C. 181-287); the Minerals Leasing Act for Acquired Lands of 1947 (61 Stat. 913; 30 U.S.C. 351, 352, 354, 359); the Geothermal Steam Act of 1970; the Federal Land Policy and Management Act of 1976; the Federal Onshore Oil and Gas Leasing Reform Act of 1987; and other legislation.

This group of minerals, including oil, natural gas, coal, oil shale, sodium, phosphate, geothermal resources, etc., has gradually been removed from the jurisdiction of earlier mining laws. As their titles suggest, the 1920 and 1947 mineral leasing acts apply respectively to original federal public domain lands and to lands acquired through purchase, gift, condemnation, etc. Principles that apply to this group are:

- title to the land remains with the U.S.,

- a specified return (royalties) must be paid on minerals extracted,

- the decision to lease is discretionary, and

- full environmental protection is required.

Salable. Governed by the Materials Act of 1947 (61 Stat. 681, as amended; 30 U.S.C. 601-602). This category includes commonly-occurring minerals of low unit value such as gravel, sand, stone, clay, cinders, etc. The Forest Service sells these materials on a price/unit basis (i.e., per ton or yard) at their appraised fair market value. Competitive sale procedures are required for large sales or where competitive interest exists.

The Region's Program

The Minerals and Geology staff of the USDA Forest Service, Northern Region, formulates policies, plans, standards, criteria, and procedures necessary for the efficient administration of the Region's minerals and geology programs. The Region assists the 13 member Forests in the orderly development of mineral resources while also protecting other surface resources and amenity values. Chapter 3 discusses environmental protection in considerable detail.

The Region's minerals and geology program is designed to accomplish these objectives in four functional areas; namely, locatable, leasable, common variety minerals, and geologic information. Managing the program involves several administrative tasks, including maintaining a minerals inventory, planning and implementing a program, assisting Forests in authorizing and monitoring minerals operations, work force management and training, and periodically assessing the effectiveness of the total minerals program.

The program is impressive in scale, contributing over 3800 jobs (primary and secondary employment) and an income of about $250 million in the States of the Northern Region in 1991.[29/] The value of the minerals produced was $262 million in 1991. The minerals program generates a substantial amount of revenue to the U.S. Treasury each year, most of which is derived from oil and gas activities. Revenue from oil and gas

[29/] U.S. Dept. of Agriculture, Forest Service, Northern Region, Lands and Minerals Program Summary Report, FY1991, 1992.

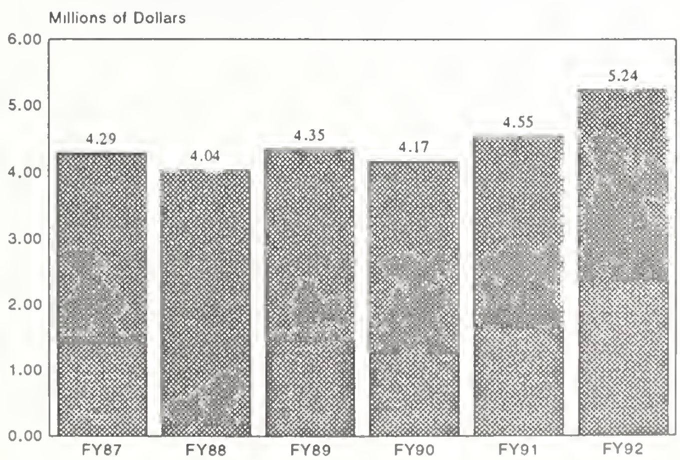
amounted to $17.6 million in 1991, with $17 million of the total coming from royalties on production. Other sources of oil and gas revenue include lease rentals, bonus bids, and seismic fees. A certain percentage of the U.S. Treasury receipts is returned to the states or counties containing the federal lands where the activities occur; and in 1991, an estimated $5.7 million was paid to Northern Region states and counties.

The interdisciplinary minerals and geology staff ensures that the Region's program is smoothly and consistently administered. It provides training, expertise, and other support services to facilitate the implementation of individual Forest programs. These include planning, permitting, monitoring and coordinating activities, and compliance with the National Environmental Policy Act, the National Forest Management Act, the Forest Service Manual, and other applicable laws and regulations. Trends in funding for the Northern Region's minerals and geology program over the past few years are shown in Figure 1-11.

A relatively new component of the minerals and geology program is related to the Forest Service's rural development initiative, which is an effort to aid resource-dependent communities in diversifying and improving their local economies with sustainable, low-impact uses of natural resources. Although locatable and leasable minerals could potentially play a role in the rural development program, the emphasis thus far has been on the quarrying and sale of building stone. The use of stone in all types of building, outdoor construction, and landscaping has increased, even through the most recent recession, and it appears that this trend will continue. Quarries are long-lived; they are stable job producers; and they typically have much less environmental impact and are not as capital intensive as many other types of mineral extraction. The Plains/Thompson Falls Rural Development Council and the Lolo National Forest have joined together in the first such project in the Northern Region to develop local stone quarries to improve the economy of the Plains/Thompson Falls area.

Figure 1-11

Minerals Funding by Fiscal Year



CHAPTER 2: The Mineral Industry and Its Operations

The U.S. mineral industry, its dynamic early leaders, and the social and economic effects of its widely scattered operations are topics of enduring historic interest. This industry's activities continue to stimulate public and agency interest and concern as the Nation pursues a goal of increased domestic production of minerals and fossil fuels, while also increasing its efforts to protect and to enhance environmental quality.

PERSPECTIVES OF MINING AND MINERALS

Individuals and groups vary widely in their perceptions of the costs and benefits of major, site-specific mineral projects. The range of possible effects is extensive and most observers tend to overlook important aspects of new project proposals. When most of the readily available information about a proposal is provided by special interest groups that favor or oppose it, the public has difficulty obtaining a balanced view of potential consequences (Chapter 3).

Social scientists, planners, and decisionmakers, who wish to understand and to predict the social and environmental effects of agency minerals programs, can also gain valuable insights by examining the mining industry's role in the overall economic system and the nature of its field operations. This chapter briefly introduces these complex subjects.

Mining and Westward Expansion

Humans have utilized minerals in their natural state for thousands of years. Prehistoric man used stones as weapons and for pounding, and later learned to chip arrowheads and crude tools from flint. Ancient civilizations fashioned jewelry, utensils, and weapons from native gold, silver, copper, and gems, and constructed buildings of stone and clay. Some Native American tribes used copper, shells, and other minerals for jewelry and as marks of status.

The history of U.S. mining and ore processing began with the English colonists along the Atlantic Coast who extracted iron ore and building materials from shallow surface mines and quarries.[1/] Iron was smelted in batches of a few hundred pounds in a charcoal furnace resembling a large blacksmith's forge. Hammersmith, Massachusetts, was the location of the first U.S. ironworks, with a furnace, rolling mill, and foundry. It was also the first of many mine-related company towns to be established in this country.[2/]

Coal, clays, and building stone were also produced in the Atlantic Coast states during the colonial period. Because of the abundance of water power, wood, and charcoal, coal was not widely utilized until the perfection and industrial use of the steam engine in the early 1800s.

[1/] For brief but colorful histories of U.S. mining, see either: USDI Bureau of Mines, <u>Mineral Industry in Early America</u>, by Hillary St. Clair, 1977; or Time-Life Books, <u>The Miners</u>, by Robert Wallace, 1976.

[2/] Allen, James B., <u>The Company Town in the American West</u>. Norman: University of Oklahoma Press, 1966.

By 1810 lead was being mined and smelted in Missouri and Illinois. A rock-lined cavity dug into a hillside served as a smelter, with other holes and connecting troughs scooped out to provide molds. As the demand for lead increased, improved smelting technology was imported from Europe. Copper was soon discovered south of Lake Superior, and Michigan became the nation's leading mining state until surpassed by Montana in 1887. Since then, various western states (currently California) have held the lead in minerals production.

The lure of gold attracted many immigrants to the New World and the search for fabled "lost" mines continues even today. The Gold Rush of 1849 brought 50,000 gold seekers to California. Hundreds of placer claims were developed in a 150 mile strip along the west slope of the Sierra Nevada Mountains. California's population doubled within 3 years and the numerous "finds" stimulated additional prospecting activity through the entire West. This period witnessed the emergence of a new personality type, the grizzled, restless prospector, and the creation of a new lifestyle, the mining community (Chapter 4).

The 130th anniversary of the discovery of the Comstock Lode, a rich vein of silver and other metals in western Nevada, was observed in 1989. The great size, depth, and immense value of this single cluster of deposits encouraged the improvement of existing mining practices and the development of new ones.

The square-set method of reinforcing mine walls and ceilings with heavy interlocking timbers was perfected at Comstock. Huge quantities of timber were required for these deeper and potentially safer mines. Ores were successfully brought to the surface from unprecedented depths (over 3000 feet), despite problems with flooding and extreme heat. On-site mills of impressive size efficiently separated metals from ores.

By 1870 the Comstock facilities had become a showplace of modern mining technology and were imitated in other mining areas of the West. In addition, the California and Nevada mining laws served as models for the Federal Mining Law of 1872.

Mineral activity in and near the Northern Region followed closely on the heels of developments in California, Nevada, and Colorado. It quickly expanded in scale, extending from the Coeur d'Alene District of Idaho to the Black Hills of South Dakota. The initial wave of placer gold mining in the 1850s and 1860s led to the founding of dozens of towns and cities, including Helena, Libby, Virginia City, Deadwood, Orofino, Elk City, Idaho City, Murray, and Bannack, Montana's first capital.

Numerous boomtowns were settled in northern and southwestern Idaho during the 1860 decade, but many were abandoned when the "diggings" were depleted. Frequently, Chinese miners worked the area for a few additional years. Florence, east of Riggins, once hosted thousands of miners, yet is now a ghost town. Silver City, southwest of Boise, and Idaho City, Idaho's first state capital, are now a fraction of their former size when the gold mines were producing.

The great silver mine at Granite, Montana, and its mill near Philipsburg were patterned after the Comstock Lode. The project was directed by the same engineer, Philip Deidesheimer, whose name was selected for the town. Granite is a classic

example of a "boom and bust" mining town, growing to a population of 3000 by 1889, declining with the silver panic of 1893, and "dying" when the mine was closed in 1913.[3/] Philipsburg, the county seat, remains.

Virginia City, Montana's territorial capital from 1865-1875, experienced a much slower population decline to about 150 people in 1970 and is now growing. Like its namesake in Nevada, it has become a tourist attraction. Founded near the fabulous Alder Gulch gold diggings, the town was laid out in 1863 and reportedly had several thousand residents within 2 years.

Helena experienced a similar mining boom but continued to grow when it was selected as the state capital. Nearby Marysville, site of the $40 million Drumlummon Mine, once rivaled Helena and was served by two major railroads.

Thus, within a single generation, about 1850-1880, much of the West was prospected and hundreds of mining camps and cities were founded. Virginia City, Nevada, was an early leader, boasting a population of 18,000 in 1880, and it supported about 100 saloons, four churches, and the best hotel between San Francisco and Kansas City. By 1900, Butte had surpassed this by mining the "richest hill on earth" for copper, zinc, and other minerals. An influx of migrants from many countries of Europe and from China provided the mine labor. Fortunes were quickly made and lavishly spent. Butte's best known copper king, William A. Clark, acquired great wealth and is remembered today for his outstanding collections of minerals (now at Montana's College of Mines and Technology in Butte) and art (at the Corcoran Gallery in Washington, DC).

Some ore deposits developed more than a century ago are still being mined. The Comstock Lode produced metals valued at $400 million before the richer ores were depleted. These mines finally closed, but portions have been reopened when the price of silver was high. The Homestake Mine in South Dakota is still a big gold producer, and, until recently, the Butte mines and Bunker Hill Mine in northern Idaho were major suppliers of copper and silver valued at tens of millions of dollars annually.

Oil Industry Growth in America

The first oil well was drilled in 1859 by Colonel Drake in Titusville, Pennsylvania. Oil became an industry in Pennsylvania, Illinois, and Ohio under the guidance of such historical figures as John D. Rockefeller and his Standard Oil Company. By the early 1900s, several prolific "gushers" had been discovered in Texas, Oklahoma, and California, and these western states had become the main oil producers in the United States. Oil and gas were not discovered until 1943 in Montana and 1951 in North Dakota.

Like hard rock mining, oil and gas development influenced communities with a boom and bust pattern of growth. Discoveries of large oil fields led to the formation of new towns such as Bell Creek, Montana. The drilling phase of development and the construction of facilities attracted relatively large workforces to remote communities. As the fields were depleted and the wells shut-in or plugged, the number of workers associated with the projects declined.

The boom and bust pattern surrounding oil and gas development is highly dependent on the price

[3/] Wolfe, Muriel. Montana Pay Dirt. Chicago: Swallow Press, 1963, pp. 246-254. (This is a well-researched guide to Montana's dozens of mining communities.)

of oil, in addition to the discovery of new oil fields. The price significantly affects number of wells drilled, the amount of production equipment installed, and thus the number of jobs created by the industry. Relatively low oil prices in the late 1960s and early 1970s caused many companies to reorganize and consolidate workforces. The Oil Embargo in 1973 and the oil shortages caused by the Iranian crisis in 1978 resulted in high oil prices worldwide. The number of drilling rigs operating in the United States skyrocketed in response to the higher prices. Communities, such as Dickinson, North Dakota, had significant increases in population as a result of the new workforce. (See Case Study 1.) As oil prices dropped in the late 1980s, the pace of drilling and development also declined.

The Mineral Industry Today

The mineral industry locates, extracts, and/or processes metals, industrial minerals, and mineral fuels. In 1987 it consisted of 33,600 firms with 700,000 employees plus smaller owner-operated units. This is more firms but fewer employees than in 1980. Thousands of additional businesses provide supplies and services for mining operations, while still others transport mineral products or convert them into a variety of forms useful in manufacturing or construction.

Central to the mineral industry are several dozen major corporations with international operations and sufficient annual sales to rank among the nation's top 500 industrial corporations. Of the 50 leading industrial corporations in 1990, 12 were oil firms.[4/] The largest oil company had annual sales of over $100 billion, exceeding all other businesses of any type. Many oil firms are now diversifying their investments to include other energy fields, metals, manufacturing, various businesses, and overseas operations.

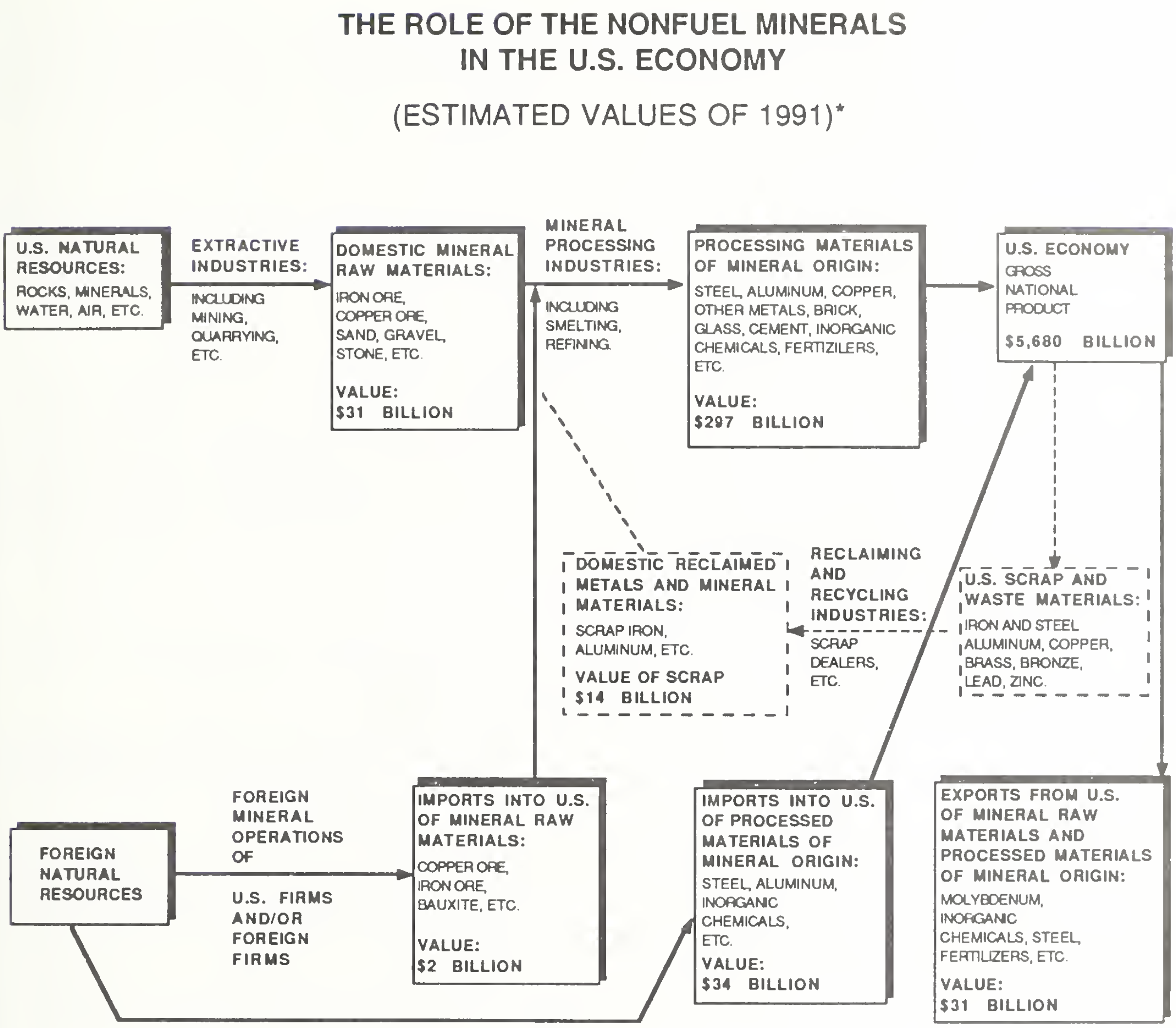
The leading coal, metal, and industrial minerals firms tend to be smaller than the major oil companies and have a narrower margin of profit. Those engaged in metals processing (e.g., producing steel, aluminum, or copper stock) have the highest sales, several exceeding $2 billion in 1990. Their investment in a single large mine or processing facility may total $100 million to $2 billion and require hundreds to thousands of employees.

The remainder of the size spectrum includes thousands of small-scale mines, local mine and oil field service firms, earth moving and drilling contractors, exploration companies, and a variety of professional consultants. Many companies have only 1 to 50 employees and confine their operations to a small geographical area. Some of them market products such as sand and gravel, ore concentrates, or exploration information. Others provide specific supplies or services on a contract basis. The trend, however, is toward consolidation to increase cost-efficiency. Some exploration, consulting, or other service firms have hundreds of employees and nationwide or worldwide operations.

The manufacturing process, in which mineral raw materials are transformed into a variety of consumer products, usually multiplies the value of these minerals many times over (Figure 2-1). This added value is very significant in the pharmaceutical industries, where a few cents worth of basic ingredients may be transformed into a drug or medicine retailing for several dollars. It is much less significant in gasoline production,

[4/] Fortune magazine, reported annually.

Figure 2-1



*December 11, 1991 (based on the statistics for first 9 months of 1991 only)

BUREAU OF MINES, U.S. DEPARTMENT OF THE INTERIOR
(based in part on U.S. Department of Commerce data)

when crude oil costs $.50 per gallon and gasoline retails for $1.15.

A growing share of the world's mineral raw materials and factory goods is now produced abroad. Since 1950, many countries such as Japan, Korea, Germany, Italy, and Taiwan have increased their productive capacity faster than the U.S. The international market is now very competitive for autos, appliances, textiles, chemicals, and other mineral products. A larger share of ore processing is also done abroad because of lower labor costs, more efficient plants, richer ore, and/or fewer pollution controls. Since about 1978, the volume of iron, copper, zinc, and lead smelted in the U.S. has been decreasing despite the generally increasing demand for these materials. Throughout this period, mining employment has declined nationally, except in the common varieties sector of the industry. The closure of smelters in Anaconda and Great Falls and the subsequent ASARCO agreement to have copper ore concentrated and smelted in Japan accentuated Montana's economic slump. The Bunker Hill mine and smelter closure gravely affected northern Idaho and, more recently, the phasedown in the petroleum industry eliminated many jobs in Montana and North Dakota (Chapter 4).

Industry Trends

According to the National Research Council, the U.S. mining industry spends most of its investment income exploring for new deposits and acquiring mineral rights.[5/] Much less emphasis is given to improving the technology for extracting and concentrating low-grade ores. Industry-sponsored research and development tends to focus on immediate problems and their short-term solutions.

Outsiders often stimulate needed changes. For example, equipment manufacturers research the miner's needs, develop new products, and demonstrate their utility and cost-efficiency. Social and environmental legislation and agency policies induce changes in the way mining companies relate to the public, their employees, and the natural surroundings where their operations are located.

Today the mineral industry faces a combination of growing foreign competition, increased social and environmental constraints, and a diminished probability of finding large, readily accessible high-grade deposits. These conditions encourage the industry to:

- design mines, plants, and well sites that meet environmental standards,

- increase the efficiency of existing operations, or close them down,

- look for minerals on public lands, where they are often relatively inexpensive,

- seek federal assistance, such as tax incentives for new domestic ventures,

- call for relaxed environmental policies and standards, and

- diversify by investing some profits in other industries.

[5/] National Research Council. Technology Innovation and Forces for Change in the Mining Industry, p. 15.

Whatever the incentives, many significant changes in industry policies and practices have occurred in recent decades. One trend is the shift of petroleum exploration dollars to overseas ventures. While many U.S.A. oil companies are decreasing their overall exploration and productions budgets, they are increasing the amount of money they spend outside the United States.[6] Lower oil prices along with higher finding and lifting costs in the U.S. have raised the minimally profitable field size, but the probability of discovering large fields in the U.S., particularly in the lower 48 states, is generally regarded as low due to the amount of exploration that has already occurred. Thus, U.S. companies are placing more emphasis on overseas targets. Data collected by the Energy Information Administration from 23 major U.S. energy companies indicates that the fraction of exploration and development expenditures in foreign areas rose from 26 percent in 1985 to 49 percent in 1989.[7]

Anecdotal evidence suggests that, because of such factors as higher environmental mitigation costs, the length of time required to obtain necessary permits, and restrictions on access to public lands, the U.S. mining industry is also focusing more on foreign prospects. Annual surveys conducted by the Society of Economic Geologists show, however, that the percent of total exploration expenditures by U.S. companies in foreign areas has actually declined over the past several years, dropping from 38.3 percent in 1980 to 33.6 percent in 1989.[8] Caution should be exercised in using these figures, because the sample does not include all companies and the response rate was deemed unusually low for 1989. Also, it is possible that any shifting of exploration effort toward foreign areas has occurred since 1989 and will be reflected in future surveys.

There is also a trend toward greater mechanization and automation in mining operations. This reduces costs because much greater volumes of ore can be handled with fewer employees per unit of production. Many tedious and dangerous jobs are eliminated.

The properly designed modern mine is an improved workplace. Recent innovations (not equally evident in all mines) include:

- effective ventilation, lighting, and drainage,
- appropriate safety measures,
- more efficient, less hazardous equipment,
- safer and more dependable blasting techniques,
- massive drills for boring shafts and tunnels, and
- new mining techniques that permit a larger portion of the workforce to remain on the surface.

Mining productivity has not uniformly increased with the improvement of working conditions.[9] For example, the amount of coal removed per man-shift in underground mining declined from 15.9 tons in 1968-1969 to 8.5 tons in 1976. This

---

[6] "Industry Adjusts 1992 E&P Budgets", Oil and Gas Journal, July 27, 1992.

[7] Department of Energy, Energy Information Administration, Performance Profiles of Major Energy Producers, 1989.

[8] Society of Economic Geologists, "Mineral Exploration Statistics," Economic Geology, various issues.

[9] National Research Council, p. 20-21.

was attributed in part to a loss of work force dedication and also to the requirements of the Mine and Health Safety Act of 1969. In contrast, surface mine production was 25.5 tons per man-shift in 1976 and recovered 90 percent of the seam, versus 55 percent underground.[10] This degree of efficiency encourages strip mining, despite the increased costs associated with environmental protection.

Further development of open-pit mining technology using huge diesel or electric shovels and enormous trucks, bulldozers, and carryalls resulted in a shift away from more hazardous and expensive underground mining techniques. A growing portion of the ore extracted in the U.S. comes from surface mines. The Berkeley Pit copper mine in Butte, begun in the 1950s and recently abandoned, was an open-pit operation that engulfed dozens of earlier shaft mines. Huge open-pit mines in Utah, Arizona, and New Mexico now account for most of our domestic copper production. Underground techniques are still used where the overlay of soil and rock (overburden) is too thick to be removed economically, or it is environmentally prohibitive to do so.

The perfection of the electrolytic reduction process made refined aluminum available at a much lower price. It became a suitable substitute for copper, lead, zinc, and steel when weight reduction was important.

The invention of many different plastic materials with widely varied characteristics provided suitable substitutes for metals in many situations where low cost, light weight, resistance to corrosion, or good insulation are desired qualities. The U.S. demand for plastics increased 2000 percent between 1950 and 1980 to 20 million tons.

The development of disposable packaging, especially metal, glass, and mineral-based plastic containers, has increased consumption and waste of mineral products. "Planned obsolescence" has similar results. This refers to the design of products that quickly wear out or become obsolete following the introduction of newer models that are of similar quality but more fashionable in appearance.

Some increase in minerals recycling has occurred, stimulated by rising costs of metals and energy, and the desire to reduce waste. Recycling of aluminum cans is particularly effective, requiring 10 percent as much energy as making new cans, and by 1990 the majority of new cans were made from recycled aluminum. However, of 18 scrap metals monitored by the Bureau of Mines, recycled metals exceeded 20 percent of total consumption in only three cases in 1977. More recent EPA data show some improvement, with 6 percent of ferrous metals, 32 percent of aluminum, and 65 percent of other nonferrous metals recovered from municipal solid wastes in 1988.[11]

THE SCOPE OF MINERAL ACTIVITIES

"Mineral activities" refers to the total sequence of operations necessary to locate, permit, extract, and process mineral commodities for market. With some minerals (e.g., sand, salt, limestone), this is a relatively simple procedure. The material is abundant, easy to recognize and requires

[10] National Research Council, p. 23.

[11] Statistical Abstract of the United States, 1991.

only minor processing to be useful. For other commodities (e.g., plutonium, duralumin, beryllium) the process is much more complex and requires more elaborate facilities. This is the case with most metals, which are usually found in subsurface ore bodies and are difficult to locate and extract. In addition, the desired metal may exist in low concentration and extensive processing is necessary to recover it and to dispose of waste materials.

Thus, the number, type, and sequence of mining activities vary with the type of mineral and with the nature of the deposit in which it is found. Gold, for example, may be found as nuggets, dust, or flakes in stream beds; embedded as visible or invisible particles in quartz or other rock; or as a very minor component of mineral compounds. Oil varies considerably in its chemical composition from one geographic area to another and also in the way in which it is deposited; e.g., whether free-flowing, in deep or shallow pools, embedded in sand or shale, etc. Each situation offers quite different challenges to the petroleum engineer.

Large-scale mining operations are unlikely to occur unless there is a fortuitous combination of accessible ore, appropriate technology, available manpower, receptive markets, and enough political support to permit the activity. But commercially valuable mineral deposits exist at specific, widely-scattered locations, including the earth's torrid and frigid zones, on mountain tops, deep in the earth, and beneath the seas. As technology improves, the frontiers of mining are extended.

Mining must compete with other established surface uses. Because of their weight and increasingly low concentrations, ores must be processed near the mine or in port cities to and from which they are easily transported. Unlike gas, oil, and coal, many minerals are heavy and abrasive, and difficult to convey long distances by pipeline. The production of many mineral commodities requires the disposal of large quantities of wastes and results in air, water or soil pollution if the process is not carefully managed.

Mine development is usually a 5- to 15-year process from exploration and discovery to initial production. It is a high-risk venture requiring a major investment decision based on careful estimates of commodity needs, consumer preferences, labor and energy costs, and the market situation for a generation or more into the future.

Minerals technology has evolved to the point where minerals can be extracted from depths of a mile or more in all climatic zones, and from continental shelves—if the reserves are rich enough to justify the social, economic, and environmental costs. Moreover, modern mining and processing technology is capable of avoiding many of the adverse effects of earlier operations, some of which are now being closed because of pollution or other health violations. Newer operations tend to be large in scale, capital intensive, and carefully planned in advance from site construction to reclamation.

Because of the great variation in mineral activities, a comprehensive discussion would fill a thick volume. In this report they are briefly described from two perspectives. First, selected methods of mining are reviewed, including those most used on National Forest lands. The discussion then focuses on copper in order to summarize the entire sequence of mineral activities

involved in the exploration, development, and production of one important metal.

Copper has been produced in Idaho and Montana for more than a century and its cumulative market value exceeds any other metal extracted in the Region. It often co-exists in compounds with lead, zinc, silver, antimony, gold, or other minerals and a similar sequence of operations (differing in details) is required for extracting and processing each of these minerals.

SURVEY OF MINING METHODS

Mining is the process of extracting specific minerals or ores and usually includes any on-site efforts to remove some of the unwanted materials or wastes in which the desired mineral is embedded. For example, a fairly good ore today might be a 1.2 percent copper, .03 percent lead and .005 percent silver. These are separated out and the remaining 98.765 percent is considered waste material (tailings).

Surface mining methods are used when an ore body is large and close to the surface. Unwanted material (overburden) is first removed and the exposed ore body is broken up and hauled out. Excluding coal, sand and gravel, and stone, this method yielded 86 percent of U.S. and 57 percent of world crude ores in 1975.[12/] When ores (or coal) are deeper, but rich enough to justify their removal by sinking shafts and transporting workers beneath the surface, underground mining techniques are used. Some modern mines employ both strategies.

Other methods blur this distinction by removing and sometimes processing minerals underground, using heat, chemicals, or equipment controlled from surface locations. This is called "in situ" mining or processing. The more common mining methods are briefly introduced below. More detail is provided in sources listed in the bibliography.

Surface Mining

This includes open pit, strip, placer, and quarry mining. In each case the miner removes unwanted materials (overburden) and extracts ore or other materials thus exposed, moving downward as the excavation progresses. These four types differ in other respects.

Open-Pit Mining: (Figure 2-2). Minerals, especially metallic ores, are extracted from a compact ore body or seam near the surface. Vegetation is removed, topsoil is stockpiled, and unwanted material is transported to a dump site. The exposed ore body is fragmented (a section at a time) with explosives and loaded on trucks or trains. The ore is hauled out of the pit via a special roadway to a nearby plant site for crushing and concentrating. The mine is abandoned when the ore body is depleted or the removal of additional overburden becomes too expensive due to its increased thickness at the edge of the pit. Following abandonment, topsoil can be replaced and native grasses or shrubs are replanted.

Quarrying: (Figure 2-3). Building stone (such as slate or limestone) or gravel is extracted from a surface deposit. Vegetation and topsoil are first removed and any remaining overburden is cleared away. Exposed material is removed and utilized without chemical alteration or expensive processing. Gravel may be screened to assure uniform size. Stone is drilled, broken away with

[12/] Engineering and Mining Journal, Operating Handbook, Volume 2, New York: McGraw-Hill, 1978, p. 2.

explosives and crushed or cut into blocks of specified sizes.

Strip Mining: (Figure 2-4). This method is commonly used when minerals such as coal, tar sands, uranium, gravel, and phosphate are deposited in layers (seams) near and parallel to the surface. Long strips are surveyed, topsoil is stockpiled, and overburden is removed. Large power shovels load the exposed mineral on trucks or trains for shipment to a nearby plant where it is crushed, pulverized, or further processed to remove impurities. When one strip has been removed, overburden from the second strip is placed in the void and reclamation can begin.

Placer Mining: (Figure 2-5). Over the centuries, native metals and gemstones such as gold, platinum, tin, sapphires, garnet, and emeralds have been washed away from exposed lodes and deposited in present or former streambeds at points where the waterflow was obstructed. The dust, flakes, nuggets, or stones are mixed with sand, gravel, or other sediments and may be concentrated near underlying rock surfaces because of their weight. They are removed by gold panning, sluicing, dredging, or hydraulic (water under pressure) techniques. The water flushes the lighter materials away from the heavier particles that settle to the bottom during the extraction process.

Underground Mining

This includes conventional adit or shaft mining and may be defined to include newer techniques where desired minerals are extracted without bringing ores to the surface, especially if shafts are used and some employees work underground.

Conventional: (Figure 2-6a). Ore bodies or other deposits (salt, coal) are approached through vertical shafts and/or horizontal or sloping adits. A variety of techniques including drilling and blasting are used to remove ores which are brought to the surface for processing. Care must be taken to provide ventilation, reduce temperatures in deep mines, prevent cave-ins, and avoid flooding. Underground techniques are now used where deeply buried ores are rich enough to justify the expense and surface mining is not feasible. There is a wide variation in underground mining techniques, depending on the size, shape, depth and grade of the ore body, the strength of the surrounding rock, and other factors.[13/]

Room-and-Pillar: (Figure 2-6b). When the ore and adjacent rock are hard, the room and pillar method may be used, creating spacious caverns with ceiling supports of the original rock. The resulting chambers permit the use of large, efficient equipment and unwanted crushed rock can be returned to the mine for disposal.

Deep Well: (Figure 2-6c). A hole is bored to a pool of liquid or gaseous mineral; e.g., water, oil, natural gas, or helium. Initially, the substance may be under sufficient pressure to flow to the surface. Pumping will eventually be necessary to lift oil or other liquids when the pressure drops and additional quantities of fluid flow into the void created. Water, air or chemicals may eventually be injected through other holes to increase subsurface pressure or otherwise enhance the well's production. Deep wells are sometimes drilled at an angle to tap otherwise inaccessible deposits under parks or structures.

[13/] Engineering and Mining Journal, Operating Handbook, Volume 2. New York: McGraw-Hill, 1978, p. 2.

Figure 2-2: Open-Pit Mining

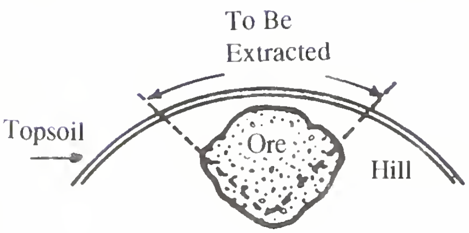


Figure 2-4: Strip Mining

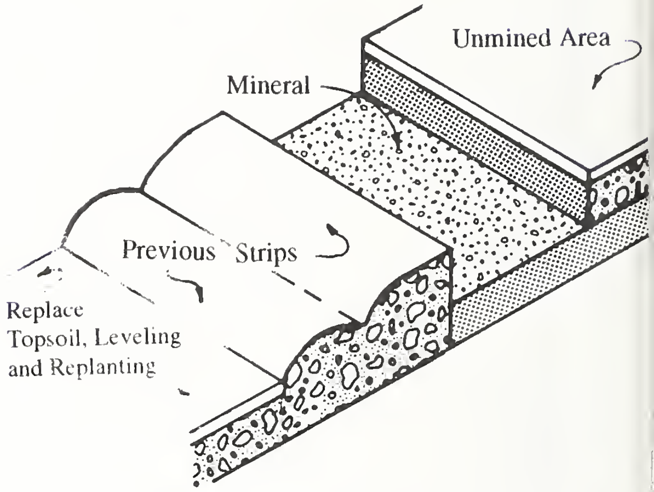


Figure 2-3: Two Types of Quarries

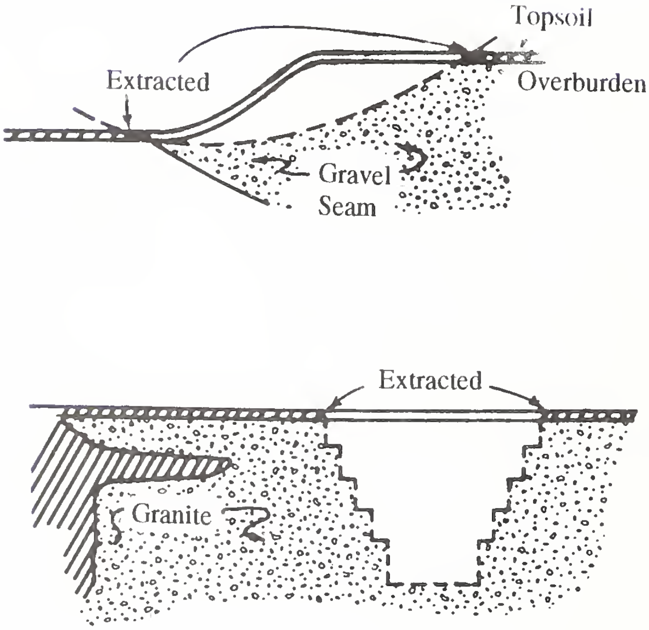


Figure 2-5: Placer Mining

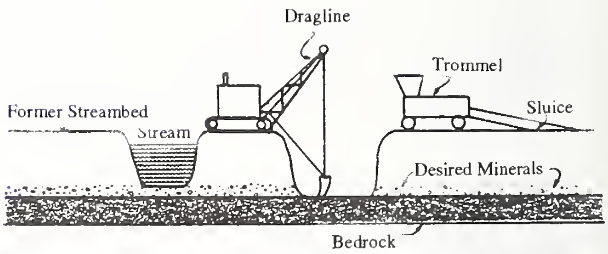


Figure 2-6a: Conventional Underground Mining

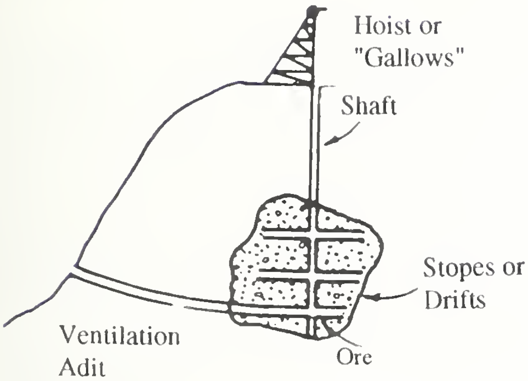


Figure 2-6b: Room-and-Pilllar

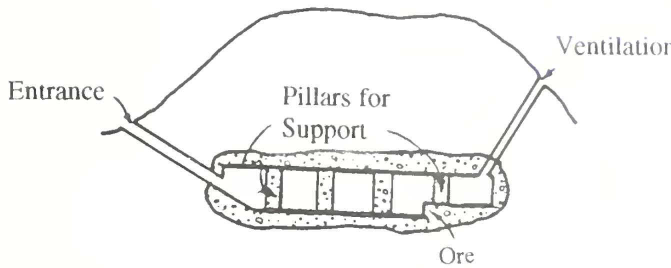
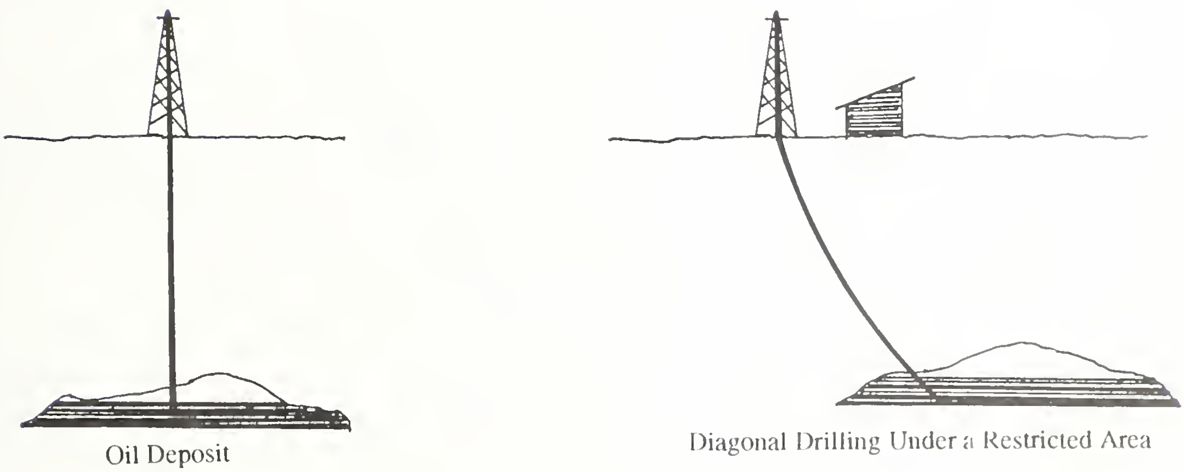


Figure 2-6c: Deep Wells



Other Methods

Solution Mining: A liquid (often water or steam) is injected down a borehole in order to melt or dissolve a mineral (such as salt or sulfur) which is then pumped to the surface. Utilizing a pipe within a pipe, the Frasch process pumps super-heated steam down the outer pipe. This melts sulfur caps or salt domes and forces the liquid up the inner pipe to be collected and solidified.

In-situ Processing: Water or chemicals are used to dissolve minerals from ores below the ground surface. Ores must first be reduced to small particles by blasting or other means and the leached minerals in solution are collected from beneath the shattered materials. This technique is being improved for use in mining copper, oil shale, and other minerals previously brought to the surface for processing.

Seawater Processing: Vast quantities of seawater are processed to recover the dissolved minerals, especially salt, magnesium, and bromine. It is not now economic to remove most other substances from seawater.

Ocean Floor Mining: Dredges process loose materials on the continental shelves up to 200 feet below sea level. Technology is now being developed to collect the metallic nodules scattered on the ocean floor. These are rich sources of several metals and industrial minerals.

Today most mineral elements and compounds (combined by nature with other materials) are first excavated from the mine and then separated out. Some of the residue (waste or tailings) may be returned to the mine, but much of it is dumped on the surface. As a result, large areas near the mine are covered with wastes and water may leach out chemicals which affect groundwater, streams, or soils.

Future mining technology appears to be moving toward in-situ mining techniques, by which desired minerals are extracted without also removing most unwanted rocks or sediments. Already this is done with oil, natural gas, steam, and in some instances, with sulfur, potash, salt, copper, and uranium. In at least some cases, surface and aquifer pollution is less serious than with other mining methods. It also reduces site acreage requirements and some of the occupational hazards of underground mining. It shows promise in lowering ore transportation and disposal costs, as well as the expense of complex processing plants with extensive anti-pollution equipment. Oil and gas exploration and development activities are discussed later in this chapter.

THE SEQUENCE OF MINING OPERATIONS

A mid-sized mining operation such as the ASARCO-Troy or Stillwater project in western Montana (case studies, Chapter 4) involves a 30- to 60-year sequence of activities beginning with surface exploration and eventually culminating with mine site reclamation. Site monitoring may extend beyond this if there is a potential for pollution or subsidence.

Because metals and their ores differ in their properties, and each geographic situation poses unique challenges, there is no single, standardized format for hard rock mining activities.

However, five general, overlapping stages common to most hard rock mining operations can be identified (Figure 2-7).

Prospecting and Exploration

Prospecting is the search for evidence of mineral deposits, a time-honored activity that continues to occur in all parts of the U.S. and the world. It is the essential first step in the mineral operations sequence.

Numerous proven and experimental methods are used to determine the existence of ore bodies and petroleum deposits. The most common techniques (in order of apparent success) are geological inference, analyzing geophysical anomalies, conventional prospecting, geochemical evidence, or some combination of these.[14] Various newer techniques are presently gaining credibility, including remote sensing, geobotanical studies, and the analysis of natural sounds.

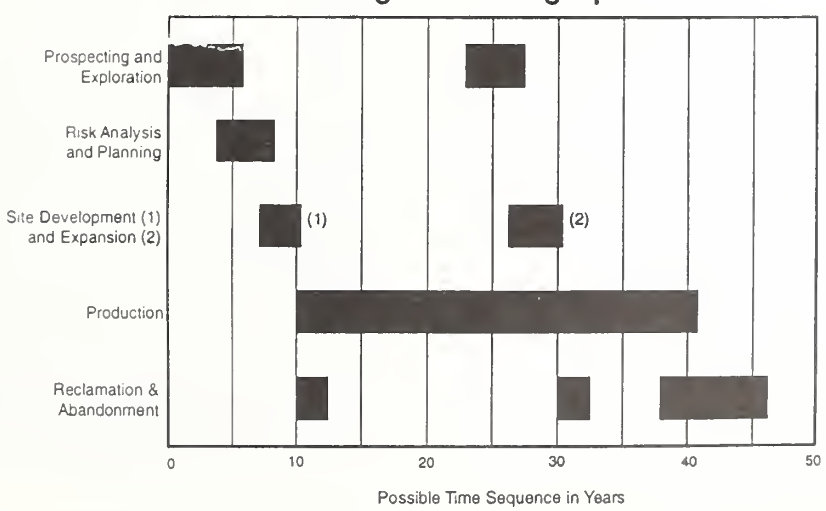
In brief, these techniques involve:

Geological inference. The presence or absence of a desired mineral is logically deduced by evaluating the available geological data. Clues may exist in an area's geological history and present surface features. The location and characteristics of known deposits of a desired mineral provide the basis for inferring additional sources. Geological inference was the initial method used in identifying 35 of 50 U.S. mine projects analyzed by Albers.[15]

Analyzing geophysical anomalies. Local deviations from the general geophysical character of an area are noted and analyzed. Examples include irregularities in the magnetic field or differences in the specific gravity of rock masses, heat flow, seismic characteristics, radioactivity, etc. A growing array of sophisticated instruments aids in locating and interpreting the significance of these features; i.e., Geiger counters, gravimeters, seismic equipment, and magnetometers. Seismic exploration for petroleum-bearing formations is described later in this chapter.

Figure 2-7

Stages of Mining Operations



[14] Engineering and Mining Journal, <u>Operating Handbook</u>, Volume 2, New York: McGraw-Hill, 1978, pp. 18-20.

[15] Ibid., p. 19.

Conventional prospecting. This begins with a systematic visual inspection of surface geology, seeking mineral outcroppings or displaced minerals that offer clues to the location of ores or lodes. It may involve digging shallow holes, breaking rocks to observe unweathered materials, or trenching with backhoes or bulldozers in order to examine subsurface features. This latter technique has the potential to be very surface disturbing but is sometimes used when explorers lack the knowledge, resources, or incentives to employ more sophisticated methods.

Geochemical prospecting. Scattered mineral samples are chemically analyzed to discover anomalies (unusual features). Then follow-up samples are taken to verify and extend the knowledge of unique chemical properties in an area. Streambed and soil samples may provide information about ore bodies at higher elevations. Biological activity or action of water often bring traces of buried ores to the surface. Core samples from small drill holes may be collected and evaluated. The chemical content of water, geothermal vapors, and vegetation may also be analyzed.

Geobotany. The distribution, growth characteristics, and chemical content of different species of vegetation are observed. Certain mosses, grasses, flowers, shrubs, and trees tend to favor or avoid particular minerals, including metals. In Montana, buckwheat is an indicator for silver. More generally in the West, goldenweed, locoweed, or poison vetch suggest the presence of selenium, uranium, or vanadium. In British Columbia certain trees are believed to be indicators for zinc (silver birch), manganese (hemlock), and molybdenum (balsam).[16]

Remote Sensing. Observations can be made from aircraft or satellites using cameras, radar, color scanning devices, or radio equipment. Photographic images are thus obtained, revealing details of topography, areas of unusual vegetation, traces of fault systems, the presence of domes overlying petroleum, anomalous soil or radiation, and water conditions. Some devices effectively penetrate cloud cover or darkness. All provide a permanent record which can be analyzed later. Clues to the location of oil and gas, copper, mercury, and diamonds have been located in this manner.[17]

When there is evidence of an ore body with development potential, the mineral rights are claimed or leased (or less commonly, the property is purchased) and more intensive exploration follows. By drilling a series of holes in a grid pattern, it is possible to determine the depth, thickness, and lateral boundaries of the ore body. The analysis of drill core samples reveals the chemical composition of each portion of the ore body.

Most prospecting and exploration efforts do not lead to a discovery. Usually ore bodies are either nonexistent, unrecognized, or lack the size and degree of concentration necessary for a commercial mining operation. Thus, the full sequence of mineral activities will occur only in high potential areas that are also available and accessible. This point can be illustrated by summarizing the experience of one major mining company over a 30-year period (Table 2-1).

[16] Engineering and Mining Journal, Operating Handbook, Volume 2, New York: McGraw-Hill, 1978, p. 47.

[17] Ibid., pp. 25-28.

Table 2-1
Ratio of Subsequent Activities to Prospecting Efforts

Locations prospected	1,000
Data warranted detailed drilling	78
Feasible to develop commercially	13
Returned costs and some profits	7
Extremely profitable	1

Source: Adapted from Rand McNally. Our Magnificent Earth: Atlas of Earth Resources, 1979.

Risk Analysis and Planning

When sufficient exploration has occurred to verify the existence of an ore body of commercial value, further analyses will be undertaken to examine the costs and benefits of extracting it. This feasibility analysis will take as long as 4 to 6 years to complete, on the assumption that it is better to spend $1 or $2 million deciding NOT to develop than to spend $100 or $200 million on a marginal or unprofitable operation.

An analysis of 50 U.S. metal mines that began production between 1940 and 1976 reveals that 6.4 years was the median length of time between the ore body discovery (or most recent rediscovery) and mine production,[18] but 14 projects took 10 years or more. This interval included site construction as well as feasibility studies and may be extended for some of the reasons discussed below.

Large amounts of capital are required "up front" for opening new mines and constructing transportation and/or processing facilities. The return on this investment is often relatively low. At this writing (1992), high energy costs, environmental protection needs, and low or unusually unstable prices for commodities such as silver, gold, copper, and zinc, are factors that must be carefully weighed prior to committing large sums of capital for new hard rock mining operations.

Because some materials are produced and exported by several different countries, international market trends must be examined. If U.S. costs for labor, pollution control, and/or severance taxes are higher than for overseas competitors, this may be offset by avoiding marginal sites, using cost-efficient technology, removing two or more metals from a given ore, or giving priority to locations with cheap power or established transportation facilities.

During this century, there has been a general decline in the quality of ores being mined in the U.S. Most of the known high-grade iron, aluminum, and copper ores are depleted, lesser grade ores are being utilized, and more ores and concentrates are imported. To cite an extreme

[18] Engineering and Mining Journal, Operating Handbook, Volume 2, page 19.

example of this transition, the original Anaconda Mine at Butte had ores assayed as high as 55 percent copper. Mines operating in 1900 commonly produced 6 percent ores.[19] Today most copper ore samples are in the 0.5 to 1.0 percent range, which helps to explain the trend toward open-pit mining.

On a smaller scale, both amateur and professional miners have revisited the long-abandoned placer deposits of Idaho, Montana, and other western states. Equipped with modern campers, trommels, motorized dry washers, or small suction dredges, they hope to extract gold that was missed by earlier miners. Their incentives included the tenfold increase in the price of gold (since 1971), the invention of efficient, low-cost equipment, and the sometimes depressed job market. There are also retired or recreational miners, who enjoy a change in activity, and prospectors or speculators who hope to locate a salable deposit.

Prior to mining, it is extremely important to have detailed information about the size, shape, and composition of the mineral deposit so that the most cost-efficient mining techniques can be selected. The cost of removing unwanted material (overburden) must be kept low. For near-surface deposits of large size, the open-pit method provides the opportunity to use huge power shovels which can scoop up 12-25 cubic yards of ore (25 to 100 tons) and load it on trucks with a 170-350 ton capacity. When the ore body is deeper and buried beneath a thick, stable layer of rock, inclined adits and the room-and-pillar method may be used. In some locations, this design provides wide ramps and gymnasium-sized rooms for the deployment of large trucks and machines.

Narrow seams of ore, on the other hand, must be much richer to justify the greater cost of the labor-intensive methods necessary to remove the ore and transport it up a shaft to the surface. Further cost considerations are the presence of numerous underground springs, very toxic chemicals, or loose or fractured rock that will require extensive reinforcement. Steep terrain, harsh climate, and the absence of all-weather roads require additional financial outlays.

Since 1960, the cost of mining machinery and equipment has increased about 475 percent (in current dollars), according to the Producers Price Index of the Bureau of Labor. During this period, the prices of many metals, with the notable exception of aluminum and copper, have increased this much or more (Table 2-2). Price increases are most pronounced for rare metals, iron alloys, and certain imported materials.

Thus mining remains a profitable venture when mineral deposits are large, accessible, and sufficiently concentrated to offset costs that rise faster than normal inflation; e.g., fuels, pollution control, and reclamation. But periodic slumps in the auto and construction industries have sharply reduced the demand for metals, depressed prices, and contributed to the closure of marginal mine and plant facilities. Depressed oil prices have also forced cutbacks in domestic oil production, especially from low-yield fields. Yet, many new mines, plants, and plant expansion projects are

[19] Further examples abound. Venezuelan iron ore was noted and ignored in the 1920s. It is now mined and available in Birmingham, Alabama, at a price below local ores because it is a high-grade surface deposit and easily transported by sea. Very little manganese is mined in the U.S. because foreign ores are cheaper, but during World War I, the Philipsburg, Montana, deposits were extensively mined. It may be economic in the foreseeable future to mine oil shale; millions of dollars have been invested in experimental projects to develop efficient methods of removing the oil and disposing of enormous quantities of waste rock.

Table 2-2
Metals Price Trends

Material	Actual Price 1960	1970	1990	1960 Price in constant 1990 dollars	1960-90 real price change (%)	1990 U.S. net import reliance as a percent of apparent consumption
Aluminum metal ($ per lb.)	.26	.29	.74	1.13	-35	exporter
Cobalt ($ per lb.)	1.54	2.20	10.09	6.69	+51	84
Copper ($ per lb.)	.32	.58	1.23	1.39	-12	3
Gold ($ per oz.)	35.00	36.41	386.91	151.98	+155	not available
Iron & Steel ($ per lb. of steel)	.062	.077	.263	.269	-2	13
Molybdenum ($ per lb.)	1.47	1.92	3.36	6.38	-47	exporter
Nickel ($ per lb.)	.74	1.28	4.02	3.21	+25	72
Platinum Group ($ per oz. of platinum)	83.00	133.00	455.00	360.41	+26	88
Silver ($ per oz.)	.91	1.77	4.82	3.95	+22	not available
Tin ($ per lb.)	1.01	1.74	3.86	4.39	-12	71
Zinc ($ per lb.)	.13	.15	.75	.56	+34	41

Source: U.S. Dept. of the Interior, Bureau of Mines, Mineral Commodity Summaries and Minerals Yearbook, various years.

being planned, considered, or constructed at projected costs ranging from $10 million to $3 billion for a single facility.[20] Most of these are at overseas locations (Chapter 1).

The end goal of planning and risk analysis is to satisfy whatever investment criteria have been established by the firm (e.g., payback period, internal rate of return). If this is not feasible, the project may be abandoned or suspended until market conditions or other limiting circumstances change for the better. Alternatively, a firm may share the risk of such a venture with interested companies and gain advantages such as increased capital, expertise, or access to production or marketing opportunities.

In compliance with the National Environmental Policy Act of 1969 (NEPA), an environmental analysis must be conducted prior to significant surface disturbances resulting from federal mineral programs (Chapter 3). States usually require a similar analysis for major state and private actions. Normally this is accomplished during the planning and risk analysis phase and provides additional information about local human and environmental needs to consider prior to site development.

Site Development

When mining appears to be economically feasible, the necessary resources (sites, labor, capital, technology, and administrative skills) are

[20] "Mining Investment 1991", in Engineering and Mining Journal, January 1991.

available, and the required permits and clearances have been obtained, site development follows. Because no two mining situations are identical, the facilities for each project must be tailored to the opportunities and limitations of each site. In hard rock mining, unique designs are necessary to accommodate local differences in topography, the nature of the ore body, the types of minerals desired, and wide variations in pre-existing facilities and services.

In an open-pit mine, development includes removing and stockpiling the topsoil for later reclamation, then uncovering the ore body—an operation that may require years to complete. In an underground mine, shafts or adits (dead-end tunnels) must be drilled to provide access to the ore body and the resulting mine waste may be used as fill to level construction sites. The site development process preceding production usually requires 2 to 5 years, depending on the rate and complexity of construction.

The copper, lead, and zinc mines of the Northern Region illustrate a number of features common to most mine and plant sites for metallic ores. These include (Figure 2-8):

- one or more underground and/or open-pit mines,

- an on-site crusher (or "mill") for reducing extracted ores to pebble size,

- a nearby concentrator for pulverizing ores and removing most of the metal particles,

- a settling pond for removing excess water from waste materials (tailings) prior to depositing them in surface dumps or returning them to the mine,

- a tailings pond for permanent storage of at least a portion of the tailings,

- level areas near the mine for parking and surface facilities,

- several surface structures, often including offices, maintenance shop and facilities for washing, changing, eating and storage. In remote areas, there may also be some housing or boarding facilities for miners.

- transportation links, as appropriate; e.g., conveyer belts from crusher to concentrator, roads to connect mines and surface installations with nearby communities, and slurry pipelines to transport wastes to the tailings enclosure,

- a power corridor and electrical substation,

- a water source (lake, creek, mine seepage, or deep wells) with storage and water pipelines,

- a railroad loading dock for loading concentrates and railroad access to a smelter where metals are extracted from the powdery concentrates.

Oil and gas field development, described later in this chapter, differs in important respects from mine site development for coal or metallic ores.

Production

Minerals production begins with extracting ores from the earth and includes crushing, concentrating, smelting, and refining. Details of the procedure vary considerably from one metallic ore to another, so the example of Butte copper ore will be used to illustrate one process. Prior to the

Figure 2-8

ASARCO - Troy Project Artist Conception of Plant Site

Source: ASARCO-Troy Project EIS

1980 closure of the Anaconda Smelter and the Great Falls refinery, all of the stages of production took place in Montana.

The history of minerals production in Butte is particularly instructive. Until 1955, some 200 different underground mines had resulted in a maze of 40 miles of shafts with an estimated 2400 miles of underground workings leading out from them. By this time, most of the rich ores had been depleted and one company had acquired all of the mines. Open-pit mining was then initiated to permit large-scale extraction of remaining low-grade ores. The Berkeley Pit was begun after first clearing over 600 acres of man-made structures and millions of tons of overburden to expose the large ore body on the east edge of Butte. This waste material was deposited in leveled mounds adjacent to the pit, and mining of the ore began.

To fragment the ore, it was necessary to drill a series of holes about 40 feet into the face of the rock.[21/] Samples were then taken to classify different segments as (1) ore (averaging 0.5 percent or more copper), (2) leaching material (about 0.2 percent), or (3) waste. Holes were then loaded with a mixture of ammonium nitrate and fuel oil and detonated, fracturing some 250,000 tons of rock. Electric power shovels with 15 to 27 yard buckets loaded the 170-ton trucks which transported the material to the crusher, leach heap, or waste dump. Ore was crushed to less than four inches in diameter and sent via conveyor belt to the concentrator where it was further reduced to a fine powder. At this stage, most of the metallic compounds had broken away from other minerals and could be removed via a flotation process. Pulverized ore was combined with water and reagents (catalysts) and blown with air to create a foam. As the resulting mixture was stirred, metal-bearing particles adhered to the foam, rose to the surface, and floated away from the remaining wastes that exited to the tailings pond. The result was a "concentrate" that averaged 26 percent copper.

The flotation process requires expensive equipment, is efficient, and has become the most widely-used method of removing base metals from ores. With the development of additional reagents, other materials can be separated in this manner. Magnetic, gravity, and other separation techniques may also be used depending on the properties of the ore and cost considerations.

Materials to be leached were placed in heaps at the rim of the giant pit and sulfuric acid was added. The copper was gradually dissolved, seeped out of the heaps, and was later recovered by chemical precipitation. This technique can also be used to extract additional copper from older mine waste dumps. These rocks are already fragmented and sometimes contain copper concentrations of 0.3 percent or higher. By varying the solvent, leaching can also be used to extract lead, uranium, sulfur, and other soluble minerals from a variety of rocks or other materials. [22/]

The ore concentrate was transported by rail to the smelter where it was "roasted" at high temperatures to remove some of the sulfur and then melted in an electric furnace. Molten copper was then transferred to a copper converter in which lighter impurities (slag) rise to the top and are skimmed off. Other waste materials were removed through the use of additives or compressed air. The copper, now over 99 percent

---

[21/] This discussion of copper production is derived primarily from Montana Copper, a 1979 publication of the Anaconda Corporation.

[22/] Additional information is found in Engineering and Mining Journal, Operating Handbook of Mineral Processing, Volume 1, New York: McGraw-Hill, 1977.

pure, was poured into molds to form ingots (anodes). Sulfuric acid was also produced as a by-product.

The copper was transported by rail to a refinery where further impurities were removed by electrolysis. The resulting 99.9 percent pure copper was cast or shaped into useful bulk copper products such as wire, bars, billets (small balls or cubes), or rods. Figure 2-9 illustrates this entire process.

The total production process requires large quantities of energy. In the case of copper, pulverizing the crushed ore is the most energy-consumptive step. With aluminum, the earlier stages are relatively simple (bauxite ore is a loose material, rich in metal), but refining (electrolysis) requires the most energy (Table 2-3).

Recycling metals requires far less energy than producing new metal from ore, an estimated 5 percent as much in the case of aluminum. Since irons and steels are over 90 percent of the tonnage of all metals produced, recycling is especially important for this industry. Less than 20 percent of U.S. steel is reused (Figure 2-1), but the example of Great Britain (where about half is recycled) demonstrates the potential for conserving both metal and energy. A major obstacle to recycling iron has been the cost of collecting and transporting this relatively low-valued but heavy metal to smelters for processing.

Abandonment and Reclamation

The life of a mine or oil field is highly variable, as the historical experience of Montana and Idaho attests. Very large ore bodies or oil pools can sustain continuous operations for a century or more, whereas small veins and many placer "diggings" may be mined out in a few months.

Large mines and their attendant ore processing facilities tend to have large work forces and to be major employers in nearby communities. Their surface activities may require hundreds or thousands of acres. Small mines, still the most common pattern despite the trend toward larger operations, require far fewer workers and a much smaller area for surface operations. However, their ratio of surface disturbance to the volume of minerals production is frequently much higher. Oil fields require relatively few employees, but

Table 2-3
Percentage Distribution of Energy Costs by Stage of Production: Copper and Aluminum

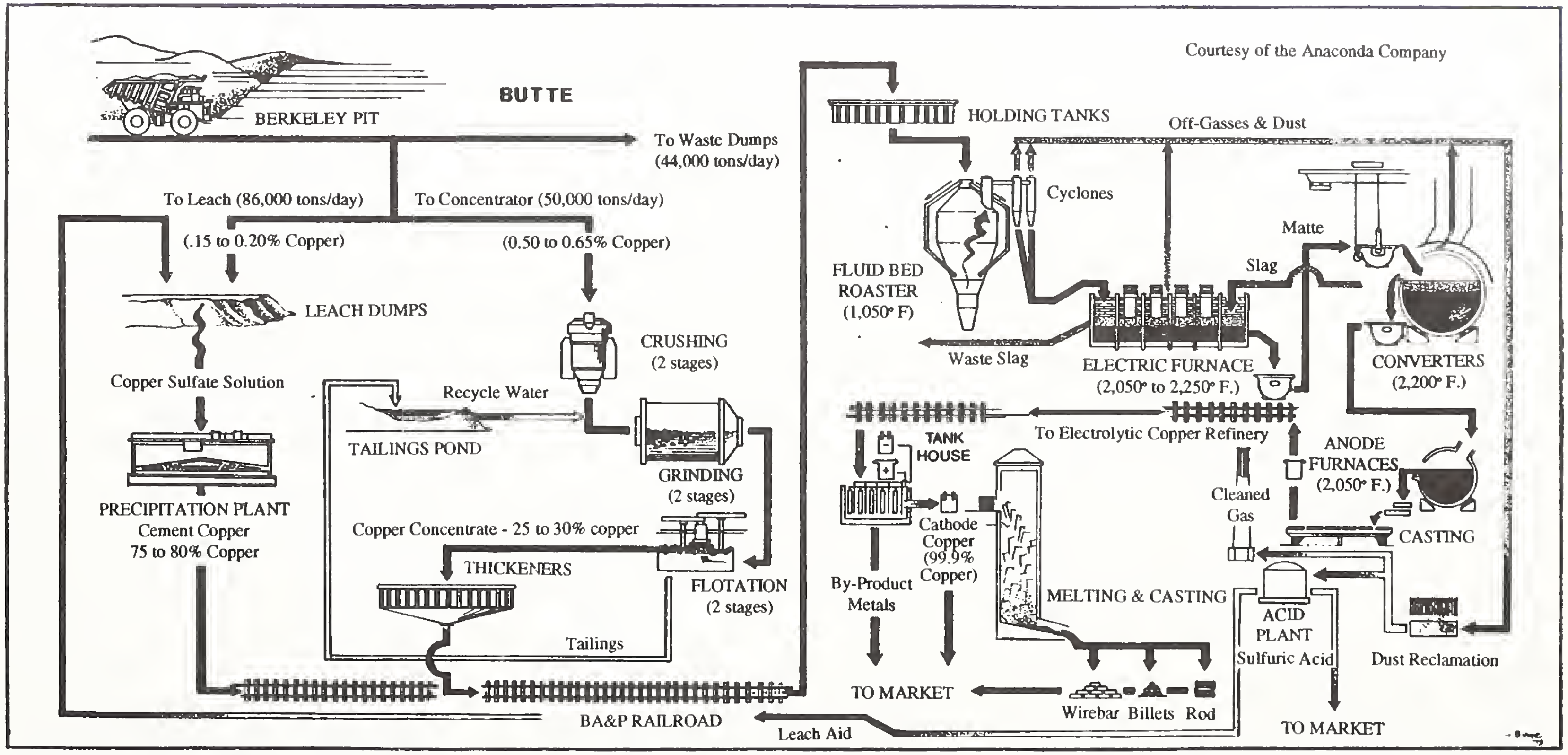
Stage	Copper	Stage	Aluminum
Open-pit mining	14%	Bauxite Mining	8.5%
Concentration (flotation)	57%	Concentration (to produce alumina)	24.0%
Smelting	17%	Electrolysis	64.5%
Refining (electrolysis)	12%	Smelting	3.0%
TOTAL	100%	TOTAL	100%

Source: United Nations. Economic of Minerals Engineering. London: Mineral Journal Books, 1976.

Figure 2-9

Mining, Concentrating and Refining Copper

Montana Production



when they are very large or a network of them exists in rural areas, the contribution to local employment is significant. Such a field will ultimately be abandoned when the oil is depleted, but may also be shut down temporarily when oil prices are severely depressed.

Reclamation is necessary throughout the life of a mining operation, beginning with the mitigation of surface disturbances resulting from exploration or site construction. Later there will be effluents to contain, facilities to erect or dismantle, erosion to manage, and changes in mining technology. Any of these could produce social as well as environmental effects.

The closure of a large mine, oil field, or processing facility has both social and environmental consequences that need to be addressed. The loss of a major employer is a traumatic experience in a sparsely-populated area (Chapter 4). The presence of an abandoned and deteriorating mine site and surface facilities is visually unappealing. In the absence of a permanent maintenance force, there is a potential for problems such as surface subsidence, acids seeping out of mine wastes, vandalism, collapsing structures, and soil erosion. Unless satisfactory surface reclamation occurs, a significant land area will have been removed from production in a time of growing need for agricultural, timber, range, and residential acreage.

Growing public concern about environmental quality during the past decade resulted in a series of federal and state laws designed to reduce long-term impacts from mining and other surface disturbing activities. The Environmental Protection Agency (EPA), the Office of Surface Mining, Reclamation and Enforcement (OSM), the Forest Service (under the National Environmental Policy Act (NEPA) and the National Forest Management Act (NFMA), the Geological Survey (GS), and various state agencies now monitor the environmental practices of mining operations and enforce the reclamation requirements specified in these laws (Chapter 3).

The Forest Service Surface Environment and Mining (SEAM) publication, "Creating Land for Tomorrow", provides illustrations of the surface effects of mining operations and a variety of reclamation techniques used to return these areas to productive use.

OIL AND GAS OPERATIONS

Petroleum operations fall into each of the general categories discussed for mining; i.e., exploration, site development, production, and abandonment. However, petroleum technology is quite unique, as the following paragraphs explain.

Preliminary exploration begins with research into what is already known about the area. Geologists also make field trips to selected sites seeking evidence of the presence of oil or gas. Seismic exploration usually follows. Seismic crews of 15-20 persons cover the terrain, using trucks, all-terrain vehicles, or helicopters to transport their equipment. A common procedure is to map out a grid over an area and to ignite a series of small charges placed in shallow holes along its lines. The recorded pattern of subsurface vibrations reveals the depth and angle of formations that may contain petroleum.

Positive findings encourage a company to lease the land, if available, and drill a "wildcat" well, the name given to a well that is drilled in a new area. In the Northern Region, deep wells are common and require a large rig with a crew of 20 or more. Temporary access roads are constructed and 2 to 5 acres of land are used for the drill pad, pumps, tanks, a mud pit, parking and loading vehicles, and other needs.

Most of this drilling and a growing share of site development and production operations are now done by independent contractors hired by an oil firm. Drilling crews usually work in shifts around the clock and sometimes spend 6 months or more drilling through 1-3 miles of rock. Historically, about 1 wildcat well in 10 yields a significant amount of oil but even fewer are profitable. With more sophisticated exploration technology, the ratio of successful wells is improving.

When a potentially profitable discovery occurs, a company usually hires contractors who continue drilling additional wells until the boundaries of the field are located. The company or its rivals are also likely to step up exploration on adjacent lands or in areas with similar geologic structures. Oil field development usually involves building all-weather roads for transporting equipment and maintenance vehicles. Other facilities, depending on the size of the field, include storage tanks, connecting pipes, salt separation plants, electrical and oil transmission pipelines, and injection wells to dispose of impure water removed from the oil.

Gas wells are less impactive socially and environmentally because they are more widely spaced, normally flow without pumps, and require fewer personnel to maintain. If the gas contains large quantities of hydrogen sulfide or another dangerous gas, a facility is constructed for removing and burning it.

When a field is completed, drilling rigs are dismantled and removed. Pumps, electrical or engine-powered, are installed to pump oil, pits are filled, and the land surface is reclaimed. A small maintenance crew remains in the area for the life of the field, which may be 20 years or more. Most oil or gas fields occupy only a few square miles, but some are much larger. The Mondak field in the northern part of the National Grasslands in North Dakota had about 500 wells in the early 1980s (see Chapter 4, Case Study 4).

Ultimately the field is abandoned and no longer a factor in the local economy. New discoveries within commuting distance may provide continuing employment for oil industry workers. Figure 2-10 graphically depicts each stage of petroleum operations.

THE CHALLENGE AHEAD

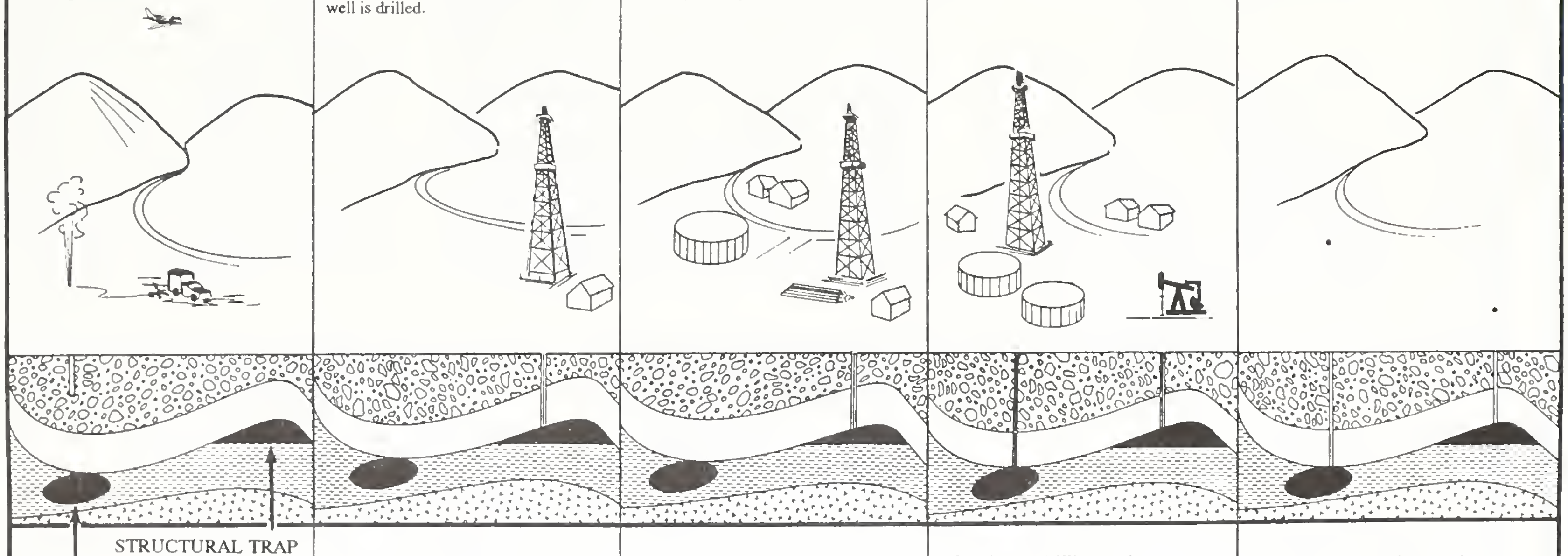
Some idea of the challenges facing future generations can be gained from a review of present reclamation needs. Each year the world mining industry produces many billions of tons of refined minerals materials. Total world minerals consumption is doubling each generation (25-30 years) as the world's population grows almost as fast. Material living standards are rising in many countries, although declining in others that lack the resources and technology to meet the needs of their people.[23/] Figure 2-11 shows the amount of these commodities produced in 1980.

[23/] U.S. Dept. of State and Council on Environmental Quality, Global 2000 Report to the President, New York: Pergamon, 1980, p. 203.

Figure 2-10

Sequence of Oil and Gas Operations

PHASE I PRELIMINARY EXPLORATION	PHASE II EXPLORATORY DRILLING	PHASE III DEVELOPMENT	PHASE IV PRODUCTION	PHASE V ABANDONMENT
(Unknown Geologic Structure) Preliminary investigations are carried out over large areas from aircraft and on the ground.	If the preliminary investigations indicate that geologic structures may contain oil and gas, a lease is obtained and an exploratory well is drilled.	If oil and gas are discovered during the exploration phase and recovery is economically feasible, the field is developed for production.	The production phase involves operation and maintenance of the field and recovery of oil and gas.	When the field is abandoned, equipment is removed, wells are plugged and the surface is reclaimed.

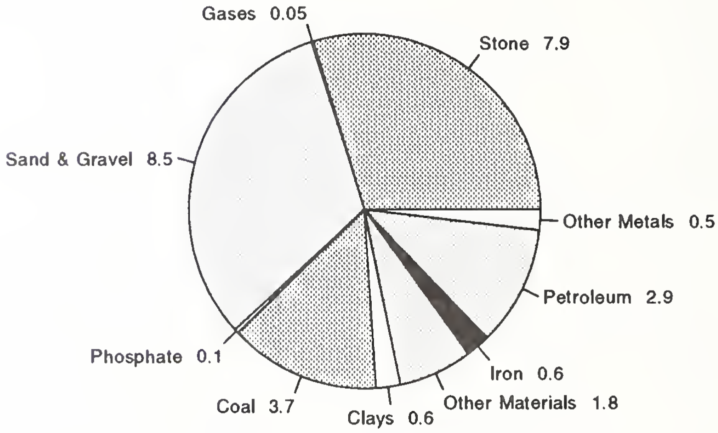


Phase I	Phase II	Phase III	Phase IV	Phase V
Airborne surveys Surface surveys Geochemical surveys Stratigraphic & Other Mapping Geophysical surveys Explosive method Thumper method Vibrator method Gravity & other methods Geologic surveys	Wildcat well drilling Access roads Camp and buildings (remote areas)	Development drilling Access roads Pipelines Utility lines Separators Storage tanks Camp and buildings	Continued drilling and development of field. Pressure maintenance system Disposal of waste Secondary and tertiary recovery system. Communication and production systems. Communities	Equipment, buildings and facilities removal. Field cleanup Well abandonment and plugging Eliminate hazard Surface reclamation Landscaping Reseeding Other erosion control

SOURCE: U.S. Department of Interior, Bureau of Land Management, 1972. Preliminary draft, Upland Oil & Gas Leasing Programmatic Environmental Impact Statement.

Figure 2-11

Annual World Production of Minerals, Including Fuels (billions of tons)



Total: 26.6 billion tons

Source: Derived from data in GLOBAL 2000 REPORT, 1980.

To produce this expanding volume of commodities, two to three times this quantity of earth material was removed and disposed of as overburden or tailings. This ratio of waste to commodity is less than 1:1 for easily accessed, naturally concentrated substances (such as stone, clays, and sand or gravel). It is 6:1 for iron, 575:1 for copper, and still higher for some precious and rare metals, averaging 9600:1 for uranium in 1976.

It is estimated that roughly 1.4 million acres, an area twice the size of Rhode Island (but half the size of an average Montana county), is disturbed each year by mining operations worldwide, excluding oil and gas.[24/] Direct effects to the land surface include removal of overburden, separating and depositing unwanted materials (tailings), constructing plants and transportation corridors, erosion, releasing pollutants that affect groundwater and soils, and displacing human and wildlife populations.

Possible environmental effects experienced by residents near the mine site include road, railroad, and pipeline construction, air and water pollution, a decline in scenic values, and a further reduction of wildlife habitat. Growing numbers of authorities are expressing concern about the general climatic and health implications of carbon dioxide, hydrocarbons, particulate pollution, acid rain, and the effects of various gases, asbestos, uranium, coal dust, mercury, and other substances on miners and local residents. Chapter 3 examines these impacts and agency procedures for dealing with them.

These trends underscore the importance of well-designed and conducted reclamation programs which either restore mined land to its original use or prepare it for another productive use such as recreation, housing, transportation, grazing, industry, or agriculture.

[24/] U.S. Dept. of State and Council on Environmental Quality, Global 2000 Report to the President, New York: Pergamon, 1980, p. 203.

CHAPTER 3: Assessing Environmental Effects

The mining and petroleum industries today are subject to intense cross-pressures. The demand for minerals and fossil fuels continues to increase with population growth and industrial expansion, especially in developing nations of the world. At the same time, the richest ore deposits and petroleum fields in the industrial countries are being depleted from generations of use. The land base on which to locate new deposits is shrinking due to competing land uses, and more rigorous social and environmental safeguards must be observed where mining is permitted.

Many industries dependent on natural resources; such as minerals, fossil fuels, timber, and grazing and croplands, are haunted by this nation's earlier history of "reap and run." Public policies encouraged and permitted rapid development of these resources. Many people who did so were not fully aware of the social and environmental consequences of their actions and accepted little responsibility for them. Today, in the face of growing public concern and increasing federal and state involvement, the more conscientious mineral and energy firms strive to produce needed commodities while avoiding or minimizing adverse impacts. Case studies in Chapter 4 illustrate this trend.

USING AND ABUSING NATURAL RESOURCES

The land area of the present United States was inhabited by about a million Native Americans when the first Europeans arrived in the early 1600s. At the time of George Washington, two centuries later, the total population of this area had increased to just 5 million. However, by 1991—two more centuries later—the nation's population exceeded 250 million and each of 40 different metropolitan areas had 1 million to 18 million people.

Frontier Philosophy of Abundance

Until this century, most people seemed to regard the nation's natural wealth as virtually limitless. Native American populations had depleted relatively few natural resources and were unaware of many potential uses. European and other immigrants established farms, mines, and settlements in accessible places with a potential for economic growth. Many of them took what they wanted from the land without much concern for environmental quality and the resource needs of future generations. Waste, as we now define it, sometimes occurred on a massive scale, such as when forests were burned to clear croplands.

These were different times. Vast forests, high mountains, wide rivers, and many wildlife species were perceived as obstacles to economic development and progress. Federal public land and immigration policies were intended to promote rapid economic growth. Various laws allowed farmers, miners, and railroads to obtain free land in return for developing natural resources. Until about 1900, public criticism of unrestricted population growth, unfettered natural resource development, and needless environmental damage was too weak and fragmented to

encourage much legislative and regulatory response. This philosophy of boundless resources was evident in many sectors of human activity, including mining, oil development, logging, hunting and trapping, farming and livestock ranching, and commercial fishing. It resulted in widespread environmental degradation, ultimately national in scope. Examples:

1. Vast acreages of virgin forests were denuded by burning and clearcutting. Results included the loss of wildlife habitat, extensive flooding, soil erosion, falling water tables, and an increase in atmospheric carbon dioxide and particulates.

2. Large areas were laid to waste by strip, hydraulic, and dredge mining, and by toxic fumes from smelters. Some locations have remained unproductive because the terrain is uneven or cannot support vegetation, and many decades are required for natural processes to restore topsoil and native vegetation.

3. Vegetative cover and soil fertility were depleted by overgrazing and annual planting of crops on dry or infertile soils. Massive wind and water erosion often followed, forcing many settlers either to utilize soil conservation techniques or to move to other areas.

4. Hundreds of species, such as bison, caribou, wolves, whooping cranes, passenger pigeons, sea otters and seals, and medically valuable plants were decimated or became extinct because of unregulated hunting, trapping, waste dumping, toxic substance spills, pesticide application, and other land-use practices.

Emerging Environmental Awareness

For more than a century, a small but articulate scattering of concerned citizens has urged this nation to respect the environment and to conserve natural resources for future use and enjoyment. Some forward-looking scientists, journalists, agency professionals, and lay citizens could envision a time when relentless population growth and generations of expanded consumption would severely degrade the natural environment and deplete the supply of critical minerals, timber, fresh water, croplands, wildlife habitat, transportation and utility corridors, and recreation lands in urban areas.

In the 1960s, many people thought the day of reckoning was at hand. World population had doubled in just 40 years and was expected to double again in another 40. United States population had increased fivefold in less than a century and per capita consumption of many resources was also on the rise. The impact of these trends on the environment was increasingly obvious, and some previously localized impacts became regional, national, or global in scope. More land was committed to food production, industrial plants, residences, highways, public and commercial services, streets and parking lots, municipal wastes, parks and cemeteries, and the other needs of an expanding population.

Dense and persistent urban smog, once common near smelters and industrial plants, was now much more widespread. Croplands, woodlands, and wetlands were converted to tract housing, and many lakes and streams became seriously polluted. Old-growth forests and the open plains

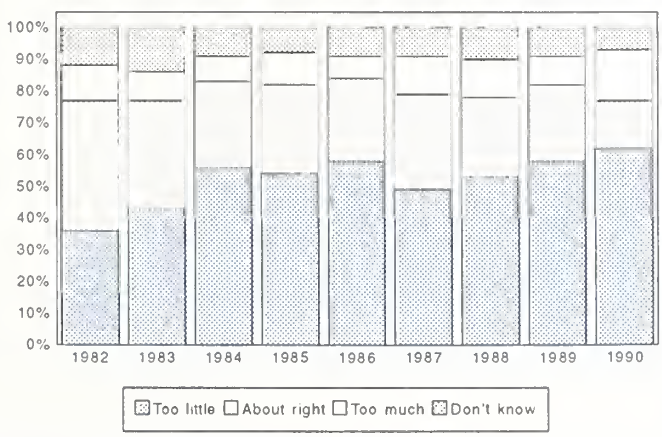
were rapidly disappearing. Many of the products of human ingenuity designed to improve the quality of life; e.g., large automobiles, insecticides and herbicides, nuclear power, and disposable products, were now perceived as potentially dangerous to human health and natural ecosystems.

A national environmental movement emerged and gained momentum throughout the 1960s and 1970s. More and more people recognized and expressed concerns about trends that affected environmental quality, human health, and the prospects of generations yet to come. Scientists, educators, local community leaders, and the communications media rose to the challenge, and "quality of life" took on new meaning. Hundreds of national, regional, and local environmental groups formed or gained membership and became a significant political force. Earth Day 1970, devoted to speeches, rallies, teach-ins, and media presentations on environmental issues, was observed nationwide. A flood of new books, magazine articles, newsletters, and pamphlets appeared to stimulate public awareness and concern for the environment. Since then, periodic national opinion surveys (Figure 3-1) have consistently demonstrated sustained public interest in protecting environmental quality and a willingness to pay for it.[1/]

Congress and many state legislatures soon responded with sweeping new laws to protect the environment from further damage, to restore environmental quality when feasible, and to eliminate some existing threats to human health and safety. Gains are already evident from some of these laws and many equally effective grass-roots initiatives. The air is now cleaner over many cities. Some lakes, streams, and wetlands

Figure 3-1

Views on Environmental Protection Efforts by the U.S. Government



SOURCE: Cambridge Reports and Cambridge Reports/Research International. See R.E. Dunlap "Trends in Public Opinion Toward Environmental Issues: 1965-1990," Society and Natural Resources, 4 (1991), pp. 285-312.

[1/] Dunlap, Riley E. "Public Opinion in the 1980's" in Environment 33 (8): 10-15, 33-36 (October 1991)

again support fish and wildlife. More people are trying to conserve energy and to recycle materials. Yet many social and natural scientists believe that we are still losing the battle on many fronts. As we grapple with one set of problems and reduce their severity, others emerge or intensify.

Today most industrial nations are dependent on imports of raw materials to maintain their living standards. Many developing nations now have population growth rates that exceed their natural resource base and their ability to provide food, shelter, and employment for all of their citizens. They harvest and export raw materials in an effort to obtain funds needed for economic development and day-to-day sustenance.

As we progress further into the 1990s, an influential minority of Americans continues to advocate almost unrestricted development of natural resources. Some of them claim that continuing population growth is no real threat at this time and that world resources are adequate if industry is free to develop them.[2/] Another influential minority takes the opposite view, arguing that we already have done serious damage to the environment and have permitted excessive population growth which thwarts efforts to protect the environment. They point out that more than a billion people in the world already suffer severe malnutrition and that remaining forests and croplands in many countries are being destroyed in an effort to provide land, food, and employment for rapidly increasing populations.

Many governments, national and international agencies, and scientific societies are now very concerned about the global character of various environmental problems. Although the scientific evidence can sometimes be rather ambiguous, many believe that rapid population growth and natural resource development are important contributors to:

- the greenhouse effect (the apparent warming of the global atmosphere due to an increase in carbon dioxide and other gases generated by human activity),

- the destruction of the protective ozone layer, primarily due to chlorofluorocarbons manufactured and released by humans,

- ocean pollution from dumped wastes, oil spills, and polluted rivers,

- acid rain (industrial air pollution which adversely affects the quality of forests and lakes),

- the destruction of tropical rain forests (by large-scale timber harvesting and burning to clear land for agriculture), and

- desertification (transformation of grasslands to desert by overgrazing, excessive cropping, depletion of water supplies, and other activities).

The emerging consensus in many countries of the world is that we must balance our appetite for goods and services with the needs of the environment. This implies sustainable resource management and increased energy conservation, materials recycling, and environmental awareness.[3/] Environmental protection is increasingly perceived as a necessary goal, a basis for improved international cooperation, and a potential source of new jobs. But how much protection is needed,

[2/] Simon, Julian and Herman Kahn. The Resourceful Earth: A Response to Global 2000. New York: Basil Blackwell, 1984.

[3/] Brundtland, Gro Harlem. "Our Common Future," in Environment 31 (5): 16-20, 40-43.

which problem areas are the most critical, and the proper roles of government and the private sector are still the subjects of considerable debate.

INCREASED FOCUS ON PUBLIC LANDS

At one time almost all of the land of the U.S. was federally owned, having been acquired in large tracts by settlement, conquest, and purchase. Today only about one-third remains under public ownership. The most desirable portions of newly-acquired tracts were granted at little or no charge to railroads, homesteaders, veterans, miners, the States, and other recipients to encourage settlement and development. Federal holdings now range from less than 1 percent of Connecticut and Iowa to about 80 percent of Nevada and Alaska, and are generally largest in the Rocky Mountain and Pacific Coast States.

The major federal management agencies and the millions of acres each manages are: the Bureau of Land Management (270), the Forest Service (191), Fish and Wildlife Service (91), National Park Service (73), Department of Defense (20), Bureau of Reclamation (5.5), Corps of Engineers (5.5), Bureau of Indian Affairs (2.7), and Department of Energy (2.2). The mineral potential on federal, state, and tribal lands is considerable (Chapter 1). Industry interest in these lands mounts as private sources of minerals, forest products, fresh water, recreation sites, and utility corridors become either depleted, too expensive to develop, or are restricted to other uses. Because of provisions in the 1872 mining law, rights to mineral resources on public lands often cost less than on private lands.

Diverse Public Expectations

In the past, it was relatively easy to get approval for mineral development on most public lands, including the National Forest System. The major barriers were physical, such as the lack of improved roads and utilities, steep terrain, or the great distance to markets or ports. When development was proposed, especially in remote areas, public concern or opposition was often insufficient to prevent it or to ensure adequate protection of other resources and careful reclamation of abandoned sites. Mining companies dealt directly with the responsible agency and let its local rangers deal with concerned publics when they existed.

For a variety of reasons, natural resource development on public lands is now much more carefully planned and monitored by both industrial firms and their host agencies. The national environmental movement made people in all walks of life more sensitive to environmental trends and concerns. Federal and state environmental legislation requires agencies and developers alike to consider the potential effects of their proposals and to make a serious effort to avoid or reduce adverse environmental impacts. A proliferation of influential environmental groups now acts as an unofficial but effective watchdog to ensure enforcement of these laws.

During the past three decades, many people—retirees, self-employed, and long-distance commuters—have moved to rural areas to escape urban crime, congestion, and pollution. "Clean" industries are also moving to rural areas, and

urban tourists visit many locations with increasing frequency. Many of these people live on the fringes of public lands or regularly visit National Parks and National Forests. They tend to oppose changes which could degrade air and water quality, scenic attributes, opportunities for recreation or nature study, historic values, or the tranquility of life in these areas.

Land management agencies now regularly interact with individuals and organizations who have quite different opinions about the best use of the remaining public lands and the amount of environmental protection that is needed. These often conflicting viewpoints are apparent in newspaper editorials and articles, in media coverage of events, and in the extensive public involvement that agencies undertake whenever major natural resource development proposals are considered. The spectrum of viewpoints is more complex than simply supporting or opposing new development and often includes all of these perspectives:

1. *Developers and commodity-oriented industries* that seek to maintain or expand their opportunities for private use of National Forests or other public lands for ski resorts, mines, oil development, timber supplies, real estate development, or livestock grazing. Their development proposals often win the support of local booster groups seeking new payrolls and increased business activity.

2. *Recreation-oriented groups*, often based in urban areas, who want increased access to National Forests for hunting, fishing, hiking, camping, skiing, floating, nature study, and off-road vehicle use. Some of these people would like to increase hunting and off-road vehicle use, whereas others would like to restrict them. Some want more modern tourist conveniences, but others would like to see fewer.

3. *Long-term residents and newer "urban refugees"* who see large-scale development, such as mines, ski resorts, or logging operations, as a threat to traditional lifestyles, rural tranquility, scenic values, and outdoor recreation options.

4. *Conservationists,* who want to manage natural resources carefully to avoid waste and to ensure that future generations have adequate supplies. They advocate incremental development, recycling of wastes, optimal use of each type of resource, and an appropriate balance of population and resources.

5. *Preservationists,* who regard some resources as vital and irreplaceable, to be protected even at high cost. They support measures to prevent cutting in old-growth forests, to ensure the survival of threatened and endangered species, to protect unique historic and geologic features, and to preserve lakes, streams, and wetlands.

Agency Response

Federal and state land and resource management agencies now make an unprecedented effort to protect and to restore environmental quality on public lands. The framework of environmental legislation enacted since 1964 gives these agencies both the responsibility and the authority to plan and to carry out environmentally compatible activities. Land managers now work with interdisciplinary teams (ID teams) of resource

specialists who understand ecological systems and follow research developments in their respective fields. Many of them are champions of environmental quality and advocate prudent use of public resources.

In the Forest Service, ID teams for major projects combine a wide range of skills, such as geology, wildlife biology, hydrology, engineering, forestry, outdoor recreation, archaeology, and economics. An ID team is able to estimate and to evaluate the potential effects of an activity such as copper mining on air and water quality, soil productivity, prehistoric sites, wildlife, recreation opportunities, or the local economy. It can provide evidence that a proposed activity should be rejected, scaled down, or modified if environmental costs are not acceptable.

Of equal importance is the increase in public participation in agency planning and decisionmaking. The Forest Service and other federal agencies now systematically inform and involve interested publics of proposed activities that affect the environment. The public is invited to critique Forest plans and project proposals, to suggest ways to improve ongoing programs, and to help to resolve issues that arise. Agency officials review both ID team findings and public comments prior to making resource management decisions and then inform interested publics of their decisions.

Each decade public interest and concern about public land management seems to intensify, as populations grow and uncommitted natural resources are fewer. No one interest sector can dictate public land and resource management policies. Agency decisionmakers have a responsibility to secure the best available information and to weigh consumer needs along with the costs and benefits of environmental protection. Sometimes competing groups are able to achieve consensus on a development proposal, and it is implemented with little or no opposition. Occasionally proposals are approved, despite active opposition, because they are consistent with laws and regulations and are judged to be in the public interest. And often proposals are either rejected or greatly modified because anticipated social and environmental costs would exceed expected benefits.

Industry Response

During the past three decades, many mining and petroleum companies have changed their environmental outlook and practices. A growing share of corporate managers accept the logic of environmentally responsible field operations. They understand the need for safeguards to protect the environment, recognize the importance of public and agency support for their activities, and see the connection between these objectives.

Some companies now inform and involve potentially affected publics in their proposals for new or expanded mineral activities. They may do this with newspaper announcements, letters, or opinion surveys to determine local needs and concerns. Some maximize hiring and training of local people to increase goodwill and to reduce the impacts of in-migration on community facilities and services. A third area of change is improved working conditions for employees, including better lighting, improved air quality

within and outside of mine facilities, and safer equipment. In many cases, the most dangerous mining operations are now performed by machines, thus eliminating some jobs, but also reducing accidents and loss of life.

LAWS GOVERNING MINERAL ACTIVITIES

Mineral exploration, development, production, and reclamation activities on public lands are governed by a complex framework of federal and state laws. One set of laws permits and encourages mineral exploration and development, acknowledging this as a national need. Another set specifies the general management responsibilities of natural resource agencies (individually or collectively), including their need to coordinate with other agencies and interested publics. A third body of law establishes standards and procedures for environmental protection.

Each agency develops regulations to guide implementation of these laws and to ensure day-to-day compliance with them. In turn, field personnel must understand and follow all applicable regulations. For example, Forest Service managers need to be familiar with appropriate directives of their own agency, the Department of Agriculture, the Council on Environmental Quality, the Environmental Protection Agency, the Bureau of Land Management, and other agencies with overlapping responsibilities. Laws and procedures of other agencies help the Forest Service to shape its own policies and procedures, which are published in its official manual (for policies) and handbook (for procedures).

Minerals Legislation

Early federal minerals legislation was intended to encourage the settlement and economic development of western lands. The General Mining Law of 1872 opened the public domain to mining activities. Its stated purpose was to encourage and promote mineral development. At 30 U.S.C. 22, the law said: ". . . all valuable mineral deposits in lands belonging to the United States . . . shall be free and open to exploration and purchase, and the lands in which they are found to occupation and purchase." This law authorizes miners to locate mineral claims on public domain lands, which make up over 73 percent of National Forest lands. Eventually, if certain conditions are met, the United States may convey title to the land within the claim to the miner.

This unrestricted mineral entry was modified in 1897, however, when the National Forest Reserves were created by the Organic Act. Congress said in that law at 16 U.S.C. 478 that while the Secretary of Agriculture could not prohibit lawful mining activities under the 1872 law, the miners had to comply with rules and regulations covering the National Forests. At 16 U.S.C. 551, the law gave the Secretary the authority to make such regulations. The existing locatable mineral regulations at 36 CFR Part 228, Subpart A, were promulgated in 1974, under this authority.

These regulations require that operations, including access conducted under the authority of the mining laws which might cause significant surface resource disturbance, must be covered by a plan of operations approved by a Forest Service authorized officer. This is generally a District

Ranger. An approved plan of operations will describe the activities to be conducted, reclamation, and measures for mitigating environmental impacts on National Forest System surface resources as a result of the proposed mineral operations. A bond may be required by the authorized officer to assure performance of reclamation according to the approved plan of operations.

Activities of little impact are specifically exempt from the plan of operations requirement. Operators who are uncertain that their operations require an approved plan may submit a notice of intent to operate. Based on that notice, a determination is made by the District Ranger that a plan of operations is, or is not, required.

The existing regulation also contains provisions that allow the authorized officer to periodically inspect the operations and issue a notice of noncompliance, if necessary. An operator aggrieved by a decision of the authorized officer may appeal that decision according to provisions of the present rule. In addition, requirements governing mineral operations within Wilderness are contained in the existing rule.

The Mineral Leasing Act of 1920 (41 Stat. 437) provides for leasing rights to specified minerals, including coal, oil, natural gas, and phosphate, on federal public domain lands. Under this Act the land remains in federal ownership, and the developer must pay rent and royalties on production. The Mineral Leasing Act for Acquired Lands of 1947 (61 Stat. 913) extends leasing privileges to most federal lands acquired through purchases, exchanges, and other means. The Federal Onshore Oil and Gas Leasing Reform Act of 1987 makes the Bureau of Land Management responsible for issuing leases on federally-owned lands, but the Forest Service must consent before leases can be issued on lands under its management. The Forest Service must also prepare any stipulations in the leases for protection of surface resources. The leasing process and subsequent exploration and development are regulated under 36 CFR 228 Subpart E, 43 CFR Subchapter C, and Onshore Orders Numbers 1 thru 7.

The Materials Act of 1947 (61 Stat. 681) and related acts extend the list of minerals, plants, and other commodities that are commercially available from federal lands, including sand, stone, gravel, pumice, cinders, clay, and petrified wood. Mining firms increasingly turn to public lands for these "common varieties" and purchase the right to mine them, sometimes through competitive bidding.

Regulations at 26 CFR 228-C further define the classification of common and uncommon minerals, making the determination relatively easy for most minerals. The authority to make these determinations is delegated to the level of the District Ranger. Most sales are also under the authority of the Ranger. A typical sale contract is for a duration of up to 1 year and requires an operating plan and often a reclamation bond.

The regulations also provide for free use, and this is often given to tax-supported organizations such as city, county, and state governments. Sales can be competitive bid or negotiated if no competition exists. An appraisal is done on all sales and no material may be sold for less than fair market value. Material may be disposed of from areas withdrawn from mineral entry only if not prohibited by law or land order and at the

agreement of the agency the withdrawal supports. Mineral materials may also be disposed of from unpatented mining claims that do not have surface rights and where the disposal will not interfere with locatable mining and use. On Bankhead-Jones Farm Tenant Act lands that are outside proclaimed National Forest boundaries, mineral material may only be disposed of to public agencies and used only for public purposes.

The Mining and Minerals Policy Act of 1970 (84 Stat. 1876) declares that it is the continuing policy of the federal government in the national interest to foster and encourage private enterprise in sound and orderly mineral development, reclamation, and research. It directs the Secretary of the Interior to carry out this policy under the applicable laws. The national Materials and Minerals Policy Act of 1980 provides further direction for implementing the 1970 act.

Other laws, such as the Geothermal Steam Act of 1970 and the Energy Security Act of 1980, reaffirm that private individuals and mining companies may claim, lease, or purchase mineral resources on most National Forest lands.

Forest Planning Legislation

The Multiple-Use and Sustained Yield Act of 1960 (74 Stat. 215) requires National Forest lands to serve a variety of purposes, such as outdoor recreation, rangeland, timber, watershed, and habitat for wildlife and fish. Lands are to be managed to ensure sustained yield of these renewable resources "in perpetuity," but both minerals development and wilderness designation are permitted when appropriate. Mining activities usually coexist with other National Forest uses but are sometimes prohibited in areas where the terrain is too steep, where it might adversely affect other resources or people, or where it could jeopardize important geological, archaeological, or scenic values.

The Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (88 Stat. 476) directs the Department of Agriculture (USDA) to prepare each decade an assessment of the nation's renewable forest and rangeland resources, both public and private. This assessment, conducted by the Forest Service in cooperation with other agencies, includes an analysis of present and projected demand for forest and rangeland resources, trends that will affect the management and use of these resources, and Forest Service programs for management and research. The Act also requires USDA (and thus the Forest Service) to submit every 5 years a recommended renewable resource program (RPA program) for the management, development, and protection of the National Forest System.

The National Forest Management Act of 1976 (NMFA) (90 Stat. 2743) amends and extends the Act of 1974 to require individual Forest land management plans which are periodically updated. These plans provide for multiple Forest uses and sustained yield of commodities and services. Each plan must be prepared by an ID team with appropriate skills and must involve interested publics at various stages of preparation. Plans establish desired levels of natural resource harvest and use and include safeguards to protect environmental quality.

Many other laws govern particular aspects of National Forest management. For example, the Forest and Rangeland Renewable Resources Research Act of 1978 authorizes research activities

necessary to compile, to develop, and to disseminate scientific information about protecting, managing, and utilizing forest and rangeland resources. The Cooperative Forestry Assistance Act of 1978 authorizes USDA to assist non-federal forest managers in promoting better management, increasing timber production, controlling forest insects and diseases, suppressing rural fires, encouraging urban forestry, improving wildlife and fish habitat, and developing more efficient wood utilization.

Environmental Legislation

Mineral operations and other commercial activities on public lands are governed by a complex array of federal and state laws, agency regulations for implementing them, and court decisions that clarify their intent.

The Creative Act of 1891 (26 Stat. 1103), which established the National Forest Reserves, demonstrated federal interest in environmental protection and conservation more than a century ago. The Organic Administration Act of 1897 identified these reserves as "national forests" and provided general guidelines for their management. The USDA was directed to "improve and protect the forest," to maintain water flows, and to supply timber. In addition, it must make necessary rules for National Forest occupancy and use and protect Forests from fire and depredations. The Forest Service was created to carry out these functions and traces its origins to this Act.

Congressional concern for the environment was again evident during the Great Depression, when various public works were undertaken to control flooding, to prevent erosion, to establish shelter belts in the Great Plains States, and to encourage soil and wildlife conservation. The Tennessee Valley Authority was created in 1933 to reduce flooding and erosion, to produce electricity, and to increase local prosperity in the Tennessee Valley. The Bankhead-Jones Farm Tenant Act of 1937 (50 Stat. 522) required the USDA to develop a comprehensive program of natural resource conservation and utilization, including erosion control, reforestation, flood control, fish and wildlife conservation, and other programs. The Department was also directed to strengthen the conservation efforts of state and local governments by providing technical assistance and loans.

In 1933 the Civilian Conservation Corps (CCC) was initiated. It created jobs, chiefly for young unemployed males, in forestry, flood control, soil conservation, wildlife protection, and park development projects. At its peak, the CCC employed 500,000 people in over 2600 camps across the country.

Several rather recent laws clarified and strengthened the environmental policies and procedures of the federal agencies. These include laws to protect wilderness areas, air and water quality, and other natural resources from avoidable harm.

The Wilderness Act of 1964 (78 Stat. 890) sets forth procedures for including selected areas in the National Wilderness Preservation System. Permanent roads are prohibited in these wildernesses, and most types of commercial and motorized activity are also excluded. An exception is made for mining activities conducted in an environmentally-compatible manner, but since 1983

no new claims can be located. The Wild and Scenic Rivers Act of 1968 (82 Stat. 906) extends similar protection to designated rivers with unique qualities that merit protection.

The National Environmental Policy Act of 1969 (NEPA) (83 Stat. 852) has been dubbed the centerpiece of federal environmental legislation. It addresses the total human environment, especially physical, biological, social, and economic conditions that could be affected by federal agency actions. NEPA also requires ongoing public involvement on environmental issues relating to federal actions. This Act is a model that scores of states and foreign governments have emulated. In combination with other environmental legislation, it has clearly reduced environmental degradation and the rate of increase in natural resource depletion in the United States. Destructive trends have been moderated or reversed in many localities.

The main focus of NEPA is evident in its Preamble (Section 2), which directs the federal government to prevent or eliminate damage to the environment and biosphere and to stimulate the health and welfare of humans. NEPA also established the President's Council on Environmental Quality (CEQ) to evaluate environmental quality, to monitor trends that affect it, to recommend national policies that will protect and enhance it, and to assess the effectiveness of federal efforts to achieve environmental quality objectives. The Environmental Quality Improvement Act of 1970 (84 Stat. 114) authorizes funding and staffing for CEQ and requires an annual report on the environment.

NEPA is supplemented by a series of subsequent acts of Congress that established new federal regulatory agencies to set and enforce environmental standards and also extended the authority of existing agencies in this area.

Table 3-1 lists many of the federal environmental protection laws passed since 1960, along with related events that have focused public and agency attention on environmental trends.

Table 3-2 identifies many of the federal agencies that set and enforce environmental standards and private nonprofit organizations that monitor and report environmental trends.

The Environmental Protection Agency (EPA), created in 1970, is an independent federal regulatory agency that was given responsibility by Congress to take the leadership role in the wide-ranging effort of regulating and enforcing the Nation's laws on protecting human health and the environment. For example, EPA sets and enforces national standards for air and water quality, emissions from pollution sources, solid and hazardous waste disposal, hazardous waste site reclamation, pesticides, radiation protection, acid rain, testing and transporting of chemicals, and noise levels. EPA also administers Superfund, a national program for hazardous substance cleanup or remediation.

OVERVIEW OF ENVIRONMENTAL PROCEDURES

The NEPA Process

The National Environmental Policy Act (NEPA) directs federal agencies, in cooperation with state and local governments and concerned public and private organizations, to use all practicable measures to ensure that humans and nature

Table 3-1
Important Environmental Initiatives since 1960

Year	Legislation or other action
1963	1955 Clean Air Act amended
1964	Wilderness Act
1965	Water Quality Act
1968	Wild and Scenic Rivers Act
1970	National Environmental Policy Act of 1969
1970	First Earth Day, April 22
1970	National Resources Defense Council established
1970	Environmental Quality Improvement Act
1970	Environmental Protection Agency created
1970	Occupational Safety and Health Act
1970	Clean Air Act amendments
1972	Federal Insecticide, Rodenticide, and Fungicide Act
1972	Use of DDT is banned in the U.S.
1972	Federal Water Pollution Control Act (Clean Water Act)
1972	U.N. Stockholm Conference to develop an Environmental Protection Plan
1973	Endangered Species Act
1974	Safe Drinking Water Act
1974	Preservation of Historical and Archaeological Data Act
1974	Forest and Rangeland Renewable Resources Planning Act
1976	National Forest Management Act
1976	Toxic Substances Control Act
1976	Resource Conservation and Recovery Act
1977	Surface Mining Control and Reclamation Act
1977	Clean Air Act amendments
1977	Department of Energy created
1980	Comprehensive Environmental Response, Compensation, and Liability Act (Superfund)
1980	Global 2000 Report to the President
1987	Montreal Protocol limiting chlorofluorocarbon production in 24 countries
1988	Ocean dumping ban
1988	NASA warns of global warming
1990	Second Earth Day, April 22
1990	United Nations foresees global warming
1990	Clear Air Act amended to control sulfur dioxide and nitrogen oxides
1990	International agreement to prohibit mineral development in Antarctica and to protect the continent's flora and fauna

Table 3-2
Agencies and Organizations with Environmental Regulatory and/or Monitoring Responsibilities

Department/ Affiliation	Organization	Established/ Consolidated
Agriculture	Agricultural Stabilization and Conservation Service	1961
	Animal and Plant Health Inspection Service	1972
	Extension Service	1862
	Forest Service	1897
	Soil Conservation Service	1935
Commerce	National Oceanic and Atmospheric Administration (includes National Marine Fisheries Service)	1970
Defense	Army Corps of Engineers	1802
Energy	Office of Conservation and Renewable Energy	1978
Interior	Bureau of Indian Affairs	1849
	Bureau of Land Management	1946
	Bureau of Mines	1910
	Bureau of Reclamation	1902
	Fish and Wildlife Service	1940
	Geological Survey	1879
	Minerals Management Service	1982
	National Park Service	1916
	Office of Surface Mining, Reclamation, and Enforcement	1977
Labor	Occupational Safety and Health Administration	1970
State	Agency for International Development	1961
Transportation	Coast Guard Federal Highway Administration	1790 1957
White House	Council on Environmental Quality	1969
Independent Federal Agency	Environmental Protection Agency	1970
Independent Federal Agency	Federal Energy Regulatory Commission	1977
Federal Advisory Group	National Academy of Sciences	1863
International	United Nations Organization Environment Program	1972
International	World Resources Institute	1982
International	World Bank	1944
International	Organization of Economic Cooperation and Development	1961
United Nations	World Commission on Environment and Development	1983
Private	National Research Council	1916
Private	The Global Tomorrow Coalition	1981
Private	Worldwatch Institute	1984
Private	Natural Resources Defense Council	1970

can exist in productive harmony, and meet the needs of both present and future generations. The requirements of the Act must be integrated with all agency planning and decisionmaking that affect the quality of the environment. Council on Environmental Quality (CEQ) regulations (40 CFR 1500-1508) provide both analysis and documentation procedures to use in complying with NEPA and also instruct federal agencies to develop supplementary measures, as necessary.

Under CEQ procedures, federal agencies must determine if any of their proposed actions may affect environmental quality. This includes agency decisions to permit commercial activities, such as mining and logging on federal lands. If environmental quality may be affected, an interdisciplinary environmental analysis is needed to determine the nature and seriousness of the effects. Certain environmental and decision documents may also be required prior to a decision to proceed with the action.

Forest Service Procedures

The environmental analysis is "triggered" when an agency or private individual or entity first proposes the action. Major objectives of the analysis are to:

- involve the public and other agencies in planning and decisionmaking that may affect the quality of the human environment,

- identify and evaluate the potential social and environmental costs and benefits of proposed actions while they are still in the planning stages, and

- enlist public and interagency cooperation in meeting essential human needs with minimal environmental impacts.

Because of widespread public interest in many Forest Service actions, the agency's NEPA procedures often go beyond the minimum requirements of CEQ regulations. The Forest Service's procedures are briefly described as follows:

1. Conduct scoping, the initial phase of environmental analysis.

a. Propose and explain the purpose of the action, even if it may occur on state or private lands. Identify responsible officials and cooperating agencies, if any.

b. Inform appropriate agencies and interested or potentially affected people of the proposed action; solicit and consider their concerns and suggestions.

c. Identify major issues that need to be resolved to reduce adverse social and environmental effects of the proposed action.

d. Determine the extent of analysis needed to understand the potential environmental effects of the proposed action and the types of documents that may be needed.

2. Continue the analysis when potential environmental effects seem evident and more information is needed to assess their extent and importance.

a. Select appropriate specialists to conduct the analysis and to prepare any necessary documents.

b. Use a systematic interdisciplinary approach that makes integrated use of the natural and social sciences and the environmental design arts.

c. Continue to involve interested and affected agencies and publics.

d. Identify reasonable alternatives to the proposed action, including "no action."

e. Estimate the physical, biological, social, and economic effects of each alternative.

f. Identify measures that would mitigate (avoid or reduce) unwanted environmental effects.

3. Document the analysis in an environmental impact statement (EIS), an environmental assessment (EA), or categorically exclude the analysis from documentation, when this is appropriate (Table 3-3).

4. Determine the most prudent agency action and inform others of the decision. It must be one of the alternatives analyzed or a modified alternative that is within the scope of the environmental analysis conducted.

5. Document the decision, when appropriate, in one of the following:

a. record of decision for an EIS,

b. decision notice for an EA (and a finding of no significant impact (FONSI), if applicable), or a

c. decision memo, if required, for certain types of categorical exclusions identified in the Forest Service Handbook.

6. Carry out the decision, including the provisions for monitoring compliance and mitigating unwanted effects.

Documentation

Three different types of documents (plus project files) are used to record environmental analysis findings. Separate documents are used to record decisions (Table 3-3). The choice of environmental analysis document depends on the potential seriousness of the environmental impacts from the proposed action and its alternatives. Different types of decision documents are used for EISs, EAs, and categorical exclusions.

Forest Service actions that may affect the environment range from mowing the lawn or controlling weeds at a local ranger station to approving the construction and operation of a large mine or ski resort with hundreds of employees and an annual income of millions of dollars. As a result, sometimes extensive scoping is needed to estimate the variety and intensity of potential impacts and to determine the most appropriate environmental procedures.

Council on Environmental Quality regulations, which provide detailed NEPA guidance, direct that federal agencies:

Table 3-3 Summary of Forest Service Environmental and Decision Documents			
Document	When Used	Why Used	Decision Document
Environmental Impact Statement (EIS)	When a proposed action may have a significant effect on the human environment (includes physical, biological, social, and economic effects of the action or its alternatives)	Agency procedures require an EIS, or the need for an EIS is determined by scoping, past experience, or identification of potentially significant effects in an EA.	Record of Decision (ROD) (whether and how to proceed with the proposed action).
Environmental Assessment (EA)	When environmental effects of a proposed action are uncertain or when a documented environmental analysis of a proposed plan, policy, or project would be helpful in decisionmaking.	To determine if an EIS is needed or to identify and mitigate potential effects of a proposed action prior to a decision. An EA is not needed if an agency decides to prepare an EIS.	Finding of No Significant Impact (FONSI) if applicable. Decision Notice (DN) (whether and how to proceed with the proposed action).
Project (or case) File for a Categorical Exclusion	When proposed actions will not have significant effects and fall within categories excluded from EA and EIS preparation in agency regulations, but require a project file to document scoping results.	Forest Service NEPA procedures specify and give examples of categorical exclusions that require a project file. All USDA and some Forest Service categorical exclusions do not require a file.	Decision Memo (DM)) (if the action requires a file and is implemented; may also be used in other instances.)

For details see: Council on Environmental Quality Regulations (40 CFR 1500-1508, July 1, 1986; Forest Service NEPA procedures (56 FR 19718-19749, April 29, 1991).

1. Prepare an environmental impact statement (EIS) if the proposed action or its alternatives may have a significant effect on the human environment or if the agency's NEPA procedures require an EIS for such actions.

A draft EIS is first prepared and circulated at least 45 days for public and agency review and comment. A final EIS is then prepared to incorporate information and insights gained from this review and subsequent analysis and field work.

Following the appropriate waiting period (40 CFR 1506.10), the responsible agency official may decide to implement the proposed action, an alternative to it, or elements of two or more of the alternatives covered in the analysis. This decision is published in a Record of Decision (ROD) and distributed to interested agencies and publics. The ROD also summarizes the alternatives considered, factors that influenced the decision, and mitigation that will be required to minimize environmental harm.

2. Prepare an environmental assessment (EA) if the need for an EIS is uncertain. Also, an EA may be prepared whenever environmental analysis and documentation would be useful in agency planning and decisionmaking.

Forest Service NEPA procedures require scoping and appropriate public involvement for an EA as well as an EIS. Even though a draft EA is not circulated for public comment, a completed EA and finding of no significant impact (FONSI) on the environment are sometimes circulated before a decision is made, especially when the public is very interested in the outcome of the analysis of a proposed action.

An EA is not required if an agency decides to prepare an EIS or if a proposed action is within a category of activities that agency regulations exclude from the need to prepare an environmental document (these are called categorical exclusions).

When an EA and FONSI have been completed, the decision to proceed with an action is recorded in a decision notice (DN).

3. An environmental document is unnecessary if an action is clearly minor and within one of the categories of actions that agency regulations exclude from environmental documentation requirements because no significant impacts normally occur. However, if extraordinary circumstances exist and environmental effects could be significant, an EIS is prepared. If the extent of the environmental effects is uncertain, an EA or EIS is necessary.

Some actions that are categorically excluded are of sufficient public and agency interest to warrant maintaining a case file which contains the names of persons and organizations contacted, the evidence that environmental effects will not be significant, and a decision memo. This memo is a concise written statement signed by the responsible official affirming that an action is being taken that is categorically excluded from documentation in an EA or EIS. Table 3-3 summarizes both environmental and decision documents and Figure 3-2 is an example of how the Forest Service coordinates with other agencies,in this case the Montana Department of State Lands, in the review of major mine proposals.

POTENTIAL ENVIRONMENTAL CONCERNS

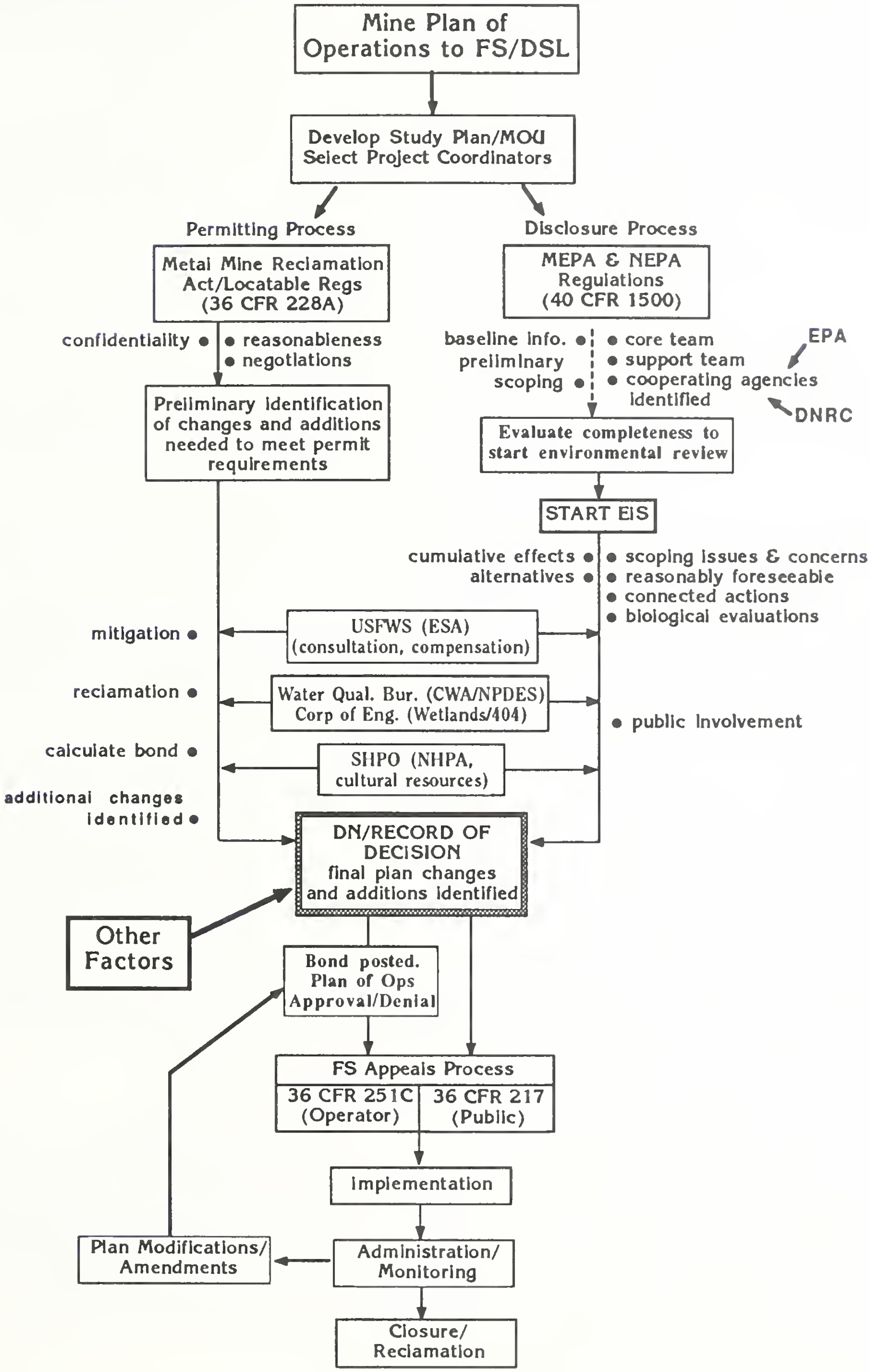
The range of potential environmental effects from major federal actions, such as Forest Service approval of a large mine, oil field, ski resort, or timber sale, is broad and usually some impacts are significant. Forest units considering such an action often decide during scoping to proceed with preparation of a EIS. Otherwise, time and money may be expended for an EA which demonstrates that significant effects are likely and that an EIS must be prepared.

An EIS (or EA) needs to identify and to evaluate all potentially significant physical and biological effects of the proposed action and its alternatives. It must also consider related social and economic effects (Chapter 4) and respond to substantive issues raised by other agencies and interested and affected publics.

The 1985 final EIS for the Stillwater Mine in Montana well illustrates the possible range of environmental effects from a large engineering project. The Forest Service and the State of Montana were joint lead agencies for this proposed project located on the Custer National Forest, about 80 miles southwest of Billings, Montana. These lead agencies conducted the environmental analysis, encouraged public participation, prepared the EIS, and responded to public and agency comments on the draft EIS. Case Study 3, Chapter 4, provides more details.

Over 20 important environmental issues were identified and evaluated. Each is summarized in the series of questions that follows.

Figure 3-2 MONTANA FS/DSL JOINT REVIEW PROCESS MAJOR MINE PERMITTING



Physical and Biological Concerns

Water quality and supply. Would water from the mine or tailings pond contaminate surface or ground water, including nearby springs and the Stillwater River? Would existing water supplies and uses be affected?

Air quality and clarity. Would the project emit harmful air pollutants and dust? Would the scenic beauty of the Stillwater Valley and Absaroka-Beartooth Wilderness be affected?

Fisheries and aquatic ecology. Would the project affect fish and other aquatic life in local streams and lakes? Would it reduce fishing opportunities and increase the cost of fisheries maintenance?

Wildlife and wildlife habitat. Would the project disrupt big game populations, including mule deer, elk, and bighorn sheep? Would it impact the bald eagle and peregrine falcon, both endangered species? Would habitat quality for other wildlife deteriorate?

Area geology and hydrology. Will the mine and pond sites increase the risk of landslides and subsidence? Will the surrounding area experience more earthquakes or floods? Will natural ground water flows be disturbed?

Land reclamation needs. Would the company successfully reclaim the area disturbed, including appropriate contours and topsoil replacement? Would topsoil that has been stockpiled for 25 years or more be sufficiently fertile and drought resistant for replanting? Will the company select trees and grasses that harmonize with local vegetation and stabilize the soil?

Wilderness quality. Would mining activities and related population growth harm the adjacent segments of the National Wilderness Preservation System? Would the Greater Yellowstone Ecosystem be affected?

Cultural and paleontological resources. Would the project disturb or destroy important historic, archaeological, or paleontological sites?

Recreation. Would the mining activity affect the quality and variety of recreation experiences in the area?

Aesthetic and historic values. Would project facilities negatively affect scenic quality, produce loud noises, or disturb historic sites?

Social, Economic and Health Concerns

Land-use patterns. Would the project change land-use patterns from agricultural to residential and commercial? Would it encourage other heavy industry to move to the area?

Employment opportunities. What new jobs and career options would the project offer, and how would this affect local workers, both employed and unemployed? Would a surplus of outsiders move into the area seeking jobs?

Local business activity. Would local businesses thrive and also expand to provide residents with a greater variety of goods and commercial services?

Income and inflation. Would the relatively high earnings of mine workers contribute to local inflation and cause resentment among workers and retirees with lower incomes? Would valued employees leave their jobs for work in the mine?

Community facilities and services. How would the resulting population increase affect county and community services; such as schools, hospitals, law enforcement, recreation facilities, water and sewer systems, and social services?

Roads, utilities, and housing. Would the mining activities and related population changes result in new housing subdivisions, additional streets and roads, and improved electrical and telephone service? Would local water and sewer systems need to be expanded?

State and local revenues. How much revenue would the mine generate for county and community governments? Would new revenues be sufficient to pay for additional facilities and services or would tax increases be necessary?

Rural quality of life. Would population growth and mine-related employment alter the traditional lifestyle of the area? Would crime, delinquency, and other antisocial behavior increase? Would qualities such as neighborliness and mutual trust deteriorate?

Traffic, noise, and litter. Would traffic become excessive in some locations, and would noise, litter, and illegal dumping of wastes increase?

Increase in hazardous chemicals. How hazardous are the mine and milling chemicals? Will controls be adequate to prevent hazardous contamination of mine facilities and surrounding air and ground water?

General Concerns

Mining technology. Will state-of-the-art technology be used to reduce social and environmental impacts and to provide safe working conditions for project employees?

Cumulative impacts. What would be the effects of an extended period of mine operation and/or the development of additional mine sites in the Stillwater Valley? Would the combined effects alter the Greater Yellowstone Ecosystem?

Mine shutdown or phasedown. What will be the impacts on the valley when the mine closes because the ore body is exhausted, or cuts back its work force when metal prices fall?

SOCIALLY RESPONSIVE MINERAL ACTIVITIES

Mining operations are of many types (Chapter 2) and occur in a wide variety of social, economic, and environmental contexts. Each new situation is unique and must be evaluated individually to estimate potential social and economic effects. Ongoing projects provide clues to possible differences in the effects of proposed projects.

Although major projects are implemented for the benefits they produce, there are always related social and environmental costs. The allocation of both costs and benefits is usually inequitable. Some people will profit; others will lose more than they gain; and the remainder may be relatively unaffected.

Nevertheless, there are important differences from one project to another in:

- the percentage of residents who perceive gains, losses, or no significant changes,
- the categories of people who gain or lose,
- the nature of the benefits earned and the costs paid, and

- the intensity of people's enthusiasm or frustration with the project.

In agency minerals program planning, it is essential to learn what factors contribute to project successes and failures. Armed with this knowledge, it is feasible to work toward a socially and environmentally responsive minerals program. Such a program could include efforts to:

- solicit and respond to public concerns about planned and ongoing mineral activities,

- identify and then avoid or mitigate adverse environmental effects from these actions,

- cooperate with other federal, state, and local agencies and private organizations to resolve common problems, and

- ensure that those who benefit most from the project also pay a fair share of the external costs.

One measure of a successful project or program is that it earns the continuing support of the clear majority of the people affected by it. This is most likely to happen when these people believe the project is necessary and that both the developers and the responsible resource agencies are maximizing local benefits and mitigating adverse social and environmental effects.

Social Impact Analysis

Social impact analysis (SIA) is part of environmental analysis. It is a procedure for collecting and evaluating information about the probable social effects of different agency alternatives, whether policy changes or proposed new activities. Along with physical, biological, and economic effects assessment, SIA is required by the National Environmental Policy Act of 1969 (NEPA) and Forest Service NEPA procedures. Hence, it is usually done as an integral part of a more comprehensive, interdisciplinary environmental analysis process (40 CFR 1500-1508; FSM 1950).

Some Forest minerals programs directly and indirectly affect thousands of people. Intelligent estimates of the probable human consequences of these programs are essential if social benefits are to be compared with costs. Such information also suggests strategies for dealing with unwanted effects when a program is implemented. Social impact analysis techniques used to acquire such data are summarized in three steps below.

1. Prepare a "baseline" portrait of the area that would be affected. Usually, there will be a local area of multiple impacts, plus one or more larger areas of more subtle effects. The baseline description reviews the total social situation, especially if the activity could or will be large in scale.

a. Identify all aspects of social life that could be measurably affected by the proposed activity. The following elements are usually included:

(1) *Socioeconomic:* Economic base, employment, income, and the present capacity of facilities and services. Include demographic data (population size, characteristics, trends, and distribution).

(2) *Sociocultural:* Social organization, traditional lifestyles, values, and issue orientations. Include political data (affected governments and their procedures for planning and responding to change), and psycho-social data (sense of security and well-being; shared sentiments about the quality of life in affected locations), if applicable.

b. Note relevant trends occurring prior to the implementation of the proposed activity that could be hastened or retarded by the proposed action.

2. Predict the most probable effects of the proposed activity on social life, as defined above. When alternatives are addressed, identify and compare the expected effects of each.

a. Identify changes that either would not occur or would emerge more slowly in the absence of the proposed minerals program. These are the social "impacts." They may appear to be either positive or negative, an evaluation that often varies with the observer.

b. If the proposed activity would occur in stages, assess the effects of each phase.

c. Consider the relationships among social, physical, biological, and economic factors.

d. Note concurrent activities, since impacts are cumulative and each additional project produces more intense effects.

3. Identify potential benefits and adverse effects (explain why and for whom), and discuss mitigating measures that could reduce or eliminate these effects. See FSH 1909.17 for additional details of the analysis process.

Social impact analysis—like weather and earthquake prediction—is a young and expanding field. The field is broad in scope and has a growing body of research from which to draw inferences about the social and economic effects of industrial development. The precision of these estimates depends on the quality of the data available for both the project and the potentially affected populations.

When effects are projected, the social scientist must know the type, scale, and expected timetable of the proposed project (plus any other concurrent development) and be familiar with the technology and sequence of operations. The social scientist's skills, experience, and opportunities for field research are critical when project-specific data are sparse. Ample time for library research, field work, data analysis, and writing is a prerequisite to plausible results.

Uses of Social Impact Analysis

Social impact analysis helps to foresee the external effects of plans and projects. It can also assist decisionmakers in several other ways by:

- identifying public concerns about existing programs, so they may be analyzed and in many cases be mitigated,

- evaluating the effectiveness of existing programs to make them more responsive to future needs,

- supplying current social data and future projections to consider along with environmental data in agency planning and permitting, and

- providing other organizations, such as local governments and civic groups with social

effects information useful in their planning and service functions.

Although some social and economic effects of a large-scale project will be felt regionally and nationally, their range and intensity are greatest at the local level. A review of ongoing mineral activities in several western locations suggests that many adverse social effects could either have been avoided or mitigated through appropriate planning or corrective action. In some cases unwanted effects were anticipated in advance but underestimated or ignored. In other instances they were not initially expected, became serious, and were difficult to remedy.

Historically, it has not been unusual for a developing firm, a federal resource agency, or a state government to sidestep responsibility for adverse social and economic effects stemming from their programs. These effects (called "externalities") are often regarded as exterior to the organization's purposes, jurisdiction, and/or budget. Even when responsible officials are willing to take preventive or remedial measures, they or their superiors may question their ability or authority to take the necessary action. When appropriate action is not taken, counties, municipalities, or other agencies must respond but may not act until the situation reaches the critical stage and is difficult to resolve. Local governments often lack the knowledge, foresight, and resources to cope with rapid changes.

Sources of Guidance and Data

Until about 1979, social impact analysis procedures were not well specified in agency manuals. Few handbooks and published data sources were available to aid novice researchers in assessing and analyzing the effects of mineral projects. Sources of data and procedures for SIA were incomplete and often limited to economic considerations. Few existing community studies dealt with mineral operations.

During 1979-85 this void was partially filled by several new publications. Forest Service Manual direction was provided (FSM 1970-1973), followed by Forest Service Handbook guidance (FSH 1909.17). Important new references (see the Bibliography) were available from commercial and agency sources, including the Bureau of Land Management. These provided both summaries of data from previous studies and detailed instructions for investigating and analyzing the effects of mineral projects.

COMPARING BENEFITS AND COSTS

The most frequently mentioned benefits of mineral development include the basic materials needed for thousands of products, reliable energy supplies, stock dividends, tax revenues, employee payrolls, and enhanced national security. These benefits satisfy important, widely-shared American values; such as wealth, abundance, independence, convenience, and novelty. Other central values, including private property, free enterprise, the opportunity to earn a profit from investments, and technological progress encourage people to produce these benefits.

The most obvious costs of mineral development can be equally varied: damage to surface resources, impacts on vegetation and wildlife, pollution of air, water and soil, displacement of some local businesses or industries, uprooting

workers and their families, and hardships for communities experiencing rapid development or decline. These benefits and costs are weighed against each other each time a major mineral development project is proposed. Other values; such as natural beauty, traditional ways of life, recreation opportunities, local control of the community's social and economic life, the need for conservation, and the depletion of nonrenewable resources are also considered (Chapter 4).

Community Polarization

Objective assessments of the benefits and costs of mineral projects are difficult to make because individuals and groups differ, sometimes widely, in the values they uphold. When a project is proposed, "prodevelopment" and "anti-development" factions tend to emerge in potentially affected communities. One set of people stresses the benefits to be derived and minimizes the adverse impacts; another emphasizes the adverse impacts and downgrades the benefits. Still others are uninformed, unconcerned, or undecided. These orientations often reflect people's home or peer influences, occupation, personal stake in the project, or philosophy of life. The outlook of most individuals is not rigid. Many people are willing to modify their outlook in the face of convincing evidence. Table 3-4 shows the range of perspectives discussed above.

Toward Informed Consensus?

Public responses to development proposals are not always as fragmented and polarized as this brief analysis may suggest. Available evidence indicates that in many project situations the majority of people take an intermediate view, especially when developers and natural resource agencies openly and honestly involve interested publics in their planning and are candid about both benefits and costs. Depending on the proposal, the modal viewpoint concerning its suitability is often near the center. Sometimes compromises are negotiated and objectional features of original proposals are remedied. A project may be dropped from consideration, reduced in scale, moved to another location, or redesigned to produce fewer impacts.

After more than a decade of interaction between those who place mineral development first and others who give priority to environment, conservation, or other options, a broad consensus may be emerging in Rocky Mountain communities. The majority of people seem inclined to support generalized statements such as these in discussions of project proposals:

1. We need a viable economy that provides:

   a. steady year-round jobs for workers, and

   b. an adequate supply of energy and factory goods.

2. We should also:

   a. require environmental safeguards,

   b. avoid boomtown conditions through phased development, and

   c. be willing to leave some resources for future generations.

Differences in opinion are often a matter of degree, rather than representing opposite poles.

Table 3-4
Spectrum of Community Viewpoints on a Major Mineral Project

FAVOR IT: WHY?		UNCERTAIN OR UNCONCERNED		OPPOSE IT: WHY?
Zealously promotes development	**Generally supports development with environmental safeguards**	**Neutral, uncommitted or ambivalent**	**Generally opposes development but not unconditionally**	**Energetically opposes development**
Expects to gain personally - money, power, or status	Job or investments at stake. Believes development need not lead to environmental ruin; we can now avoid this	Perplexed: uncertain of what position to take - costs and benefits seem equally balanced	Believes we need this kind of development but not in our locality (because of its special qualities)	Job or investments at stake. Expects to lose personally - money, power, or status
Represents an organization that expects to profit from development	Thinks the local community would benefit economically; e.g., increased spending, reduced unemployment	Organization favors it but he/she thinks costs probably outweigh benefits for the community at large	Thinks selected projects would be acceptable if carefully screened, planned, and scheduled to avoid most adverse effects	Represents an organization that expects to profit or attain its goals if development is halted
Strong personal commitment to such values as: free enterprise, progress, materialism, consumption	Thinks he/she would personally benefit, or perceives development as essential to the U.S. economy	Informed on the issue but indifferent about what happens	Thinks he/she would lose money or other values would be threatened: hunting, fishing, cheap land, local lifestyles, existing economic activities	Strong personal commitment to such values as: conservation ecological balance, preservation
Believes technology can solve any problem it creates; it is merely underutilized	Finds this the politically most expedient position to support	Uninformed; no opinion; has not thought about it	Opposes development because of peer pressure from friends, co-workers, or ethnic group	Believes the very survival of humanity is now threatened by pollution, resource depletion, or other types of environmental changes
Thinks the planet is still rich in resources and environmental degradation is manageable	Concerned about specific issues: National and Regional energy shortages, our dependence on foreign oil, international balance of payments, defense readiness, etc.	Includes: would like to be informed, might then have an opinion; do not care about it; could not do anything about it anyway	Concerned about specific issues: adequacy of natural resources for future generations, effects on wildlife, air pollution, water pollution, noise, crime, inflation, etc.	Thinks current population growth rates dictate far less per capita consumption

People disagree on how much environment protection we need (rather than on whether we need it or not), on how much mining needs to be done, and on where it is most appropriate to permit operations. The Forest Service takes pains to ensure that approved mineral projects are carefully designed with agency standards (stipulations) clearly specified in lease contracts and operating plans. Responsible officials monitor projects to observe compliance and to identify unforeseen problems. Many older mineral projects in the U.S. were developed under less stringent criteria. Some facilities are now being updated to comply with recently enacted standards, while others are being abandoned.

KEY FACTORS IN PROJECT EVALUATION

The decision to initiate, to expand, or to discontinue a large-scale mineral project is based on a careful evaluation of many conditions (variables) that determine its feasibility (Chapter 1). These same factors, summarized below, govern most of the social and environmental effects of the project and can be estimated prior to the planning and construction phases of new mine and plant facilities.

Political Climate for Change

As noted earlier, United States minerals policy had been formulated by Congress in a series of laws dating back to 1807. Successive laws often amend rather than replace earlier legislation. These laws have been interpreted by generations of federal judges whose decisions (called case law) also apply.

This framework of laws and legal decisions is implemented by the President of the United States and the heads of the various natural resource agencies. Each new president and department or agency head has some latitude to extend, curtail, or redirect existing policies by pressing for new legislation, adapting agency procedures, and adjusting priorities. State laws and executive policies and county and municipal codes and ordinances add to the network of regulations that govern federal resource managers and the minerals industry.

The federal commitment is clearly twofold: to encourage minerals exploration and production and to protect other surface and subsurface resources from undue harm. The content of new, minerals-related legislation and the emphasis accorded existing laws and policies may vary from one presidential administration to another, reflecting changing perceptions of national need, the composition of each new Congress, and the major thrusts of each President's program. A frequent criticism from the minerals industry is that the system of federal and state laws and policies is unduly restrictive and discourages domestic production and self-sufficiency. The majority of the public endorses environmental protection measures.

Agency Minerals Management Practices

Although resource agencies function within the legislative framework described above, there are time and place differences in program emphasis and effectiveness. At all administrative levels, the quality of an agency's minerals program depends on such factors as the number of personnel assigned to the minerals workload, the quality

of their training and experience, and the adequacy of their operating budget. During the past decade, the Forest Service has increased its emphasis on in-service training, both in minerals program administration and environmental protection procedures. Other factors, such as effective leadership, commitment and morale, are also important.

Economic Incentives and Constraints

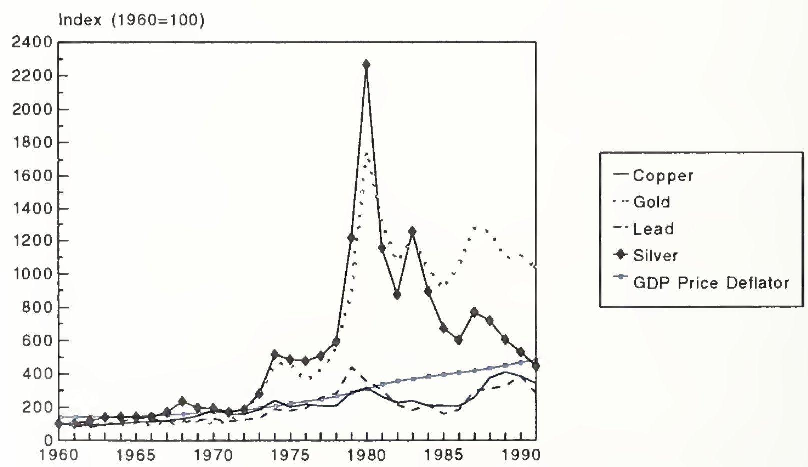
The primary goal of developers in most mineral operations is to make a suitable profit. They monitor current price trends for different minerals and a disproportionate share of capital is invested in exploration, development, and production of the most promising commodities. Potentially unprofitable minerals are likely to be imported.

Between 1975 and 1980, silver, gold, cobalt, molybdenum, platinum, tin, petroleum, and diamonds were appreciating in value much more rapidly than normal inflation. (Figure 3-3 shows price trends for selected commodities.) In the Northern Region, prospecting activity for commercial quantities of these minerals increased, especially for silver, gold, and platinum. Some abandoned mines were reopened and some tailings dumps were reprocessed.

A persistently depressed market can lead to workforce reductions, suspension of mine or plant operations, or permanent closure of less-efficient operations. Since 1980, prices of gold, silver, cobalt, and tin dropped sharply and crude oil prices declined substantially since 1982. This put a crimp on both exploration and development of new sources. Other minerals, such as copper,

Figure 3-3

Metal Price Trends and Inflation in the United States



Source: Council of Economic Advisors, Economic Report of the President, 1992, and U.S. Department of Interior, Bureau of Mines, Mineral Commodity Summaries and Minerals Yearbook, various years.

zinc, lead, nickel, aluminum, platinum, and industrial diamonds fared better during this period, even though some marginal mines did close. Managers of marginal operations are reluctant to invest additional money to improve working conditions or to reduce environmental impacts.

Rising costs of lease rentals and production royalties on private lands encourage developers to explore for minerals on federal lands where these costs are frequently lower. Even there, lease purchases by speculators can drive the price upward. The cost and productivity of labor, energy prices, and the adequacy of existing state and county roads are additional factors.

Taxes on income, property, and production are other important variables and these change with the times and differ among states and counties. High severance taxes; for example, discourage the development of marginally profitable operations. An extremely valuable deposit will enable the developer to pay premium wages, take elaborate measures to meet environmental standards, and offset unusually high costs due to depth, remoteness, etc.

Perceptions of National Needs

In time of war or other serious crises, the government may authorize, subsidize, and/or require mineral activities that would not otherwise occur. This may be done to reduce import dependence, to stockpile critical materials, or to encourage the production of substitute commodities. There may be "crash programs" in which the usual permitting and monitoring procedures are simplified. Such programs could increase the adverse effects resulting from mineral activities. Development may occur in locations where it was hitherto prohibited or considered uneconomic.

Industry's Role

The social, economic, and environmental effects of mineral activities vary considerably with individual firms. Some illustrations follow.

Level of financing. Level of financing is a key factor influencing the way mineral operations are planned and administered. Tight-budget operations encourage such shortcuts as poorly engineered roads, illegal dumping of wastes, or hiring underqualified workers. Well-financed projects can be more visually appealing, safer, and pose fewer environmental risks.

Company technology and expertise. Some firms perform their jobs competently with minimal social and environmental impacts because their employees know their work, activities are well coordinated, and the technology used is appropriate to the situation. Some routinely camouflage or landscape their facilities and protect surface resources.

Concern for employees. When a company hires and trains local workers, sponsors programs which demonstrate a concern for their welfare, and provides performance incentives, population influx impacts are reduced, and community support for the project is increased. Some companies demonstrate concern for worker health and safety, which also promotes employee performance and loyalty.

Adequacy of communication. When detailed information about proposed projects is freely available to affected communities and agencies, they are able to formulate plans for dealing with anticipated social and environmental effects. In the absence of such data, rumors and speculation flourish, and time and money may be wasted on unrealistic preparations.

Affected Environment

The location of mineral deposits is increasingly critical. There is often strong public resistance to locating mines or plants in or near areas highly valued for other uses; such as homes, schools, parks, municipal watersheds, organized recreation, wildlife habitat, historic sites, orchards, truck farms, or designated wildernesses. People expect mining activity to increase local traffic, noise, and pollution, and to disturb sites valued for their scenic or historic attributes.

Social, economic, and environmental effects tend to be the most intense, varied, and frequent in or near areas of field operations. Depending on the scale of these activities, one or more communities or counties may be affected. This is the local "area (or zone) of influence," where most of the mine and plant employees live, work, shop, and utilize public services.

Outside of this local zone, effects are more specialized and less frequent. Yet a major mine or plant may significantly affect a larger region; e.g., one or more states. A series of projects may have important national implications. The area of influence concept is described and illustrated in the Forest Service Economic and Social Analysis Handbook (FSH 1909.17).

Scope of Operations

Scope is the most critical factor in explaining the great variation in mineral impacts evident in different locations. This includes the type, scale, intensity, and duration of the activity.

Type. Exploration, site development, mineral extraction, and processing have different workforce requirements; e.g., number of workers, number of local-hire, skills needed, and duration of employment. Generally, site construction activities, ore smelters, and refineries require the largest workforces. Exploration and reclamation crews are much smaller.

Scale. In a minerals-rich area, such as the Cabinet Mountains of northwest Montana, several companies may conduct operations simultaneously, using hundreds of employees. Without coordination, some duplication of roading, drilling, mineral processing, and waste disposal operations may occur. In contrast, a single small mine may employ only 1 to 25 people and ship its ores or concentrates to distant cities for processing.

Intensity. Ordinarily, the more rapid the pace of development, the more disruptive its social effects. Adverse social and economic effects become most intense and least manageable when several companies initiate major projects in the same rural location and make no effort to coordinate their operations. Increasingly, competitors recognize the potential for cost savings, reduced environmental degradation, and fewer social impacts in cooperative ventures; such as roads, pipelines, oil field facilities, and shared data on mineral potential.

Unless the local zone has a dire and immediate need for increased economic activity, gradual development is much preferred. It offers manageable growth and prolonged economic activity for the area. Ideally, multiple projects should be coordinated so that intensive labor phase, such as plant construction, follow each other rather than occur together.

Duration. It is difficult for local communities and developers to provide adequate support services for short-term projects. The time and money required to plan, acquire permits and funding, construct and staff schools, malls, homes, or other facilities may not be sufficient. When an activity is expected to continue for a generation or more, these kinds of facilities can be constructed, and necessary loans can be repaid from increased tax revenues.

Community Capacity for Changes

A given level of development can generate quite different effects, depending on the social and economic characteristics of the local zone. A growing number of studies[4/] clarify the effects of industrial development on small towns and rural communities. Case studies of similar events elsewhere permit some generalizations about the impact of development on a community. They provide a basis for projecting changes that may occur when new projects are implemented, especially when rapid growth continues for an extended period. Some of the factors associated with these changes are reviewed below.

Community size. In general, a small community has fewer available workers and less diverse skills than a larger town, so more "imported" labor is required. Villages with less than 2000 people often lack adequate services, even for their own residents.[5/] They may not have a dentist, high school, sewer system, adequate water supply, hospital, or improved streets. They usually have nonprofessional, part-time civic administrators and do little systematic planning and zoning. Small towns are often unincorporated or their charter provides only limited authority to deal with new situations. Few local contractors are available for support services, such as drilling or construction, and these workers must also be brought in.

In contrast, most cities over 10,000 do have the personnel, housing, public and commercial facilities, and expertise to handle moderate growth routinely. A well-developed road system serves the vicinity and can be used for exploration and hauling. Both skilled and unskilled local-hire employees, some with oil or mining experience, are available, thereby reducing the need for in-migrants. A much larger increase in minerals activities would be needed to produce the level of impacts experienced in a small town.

Degree of Isolation. Project construction in sparsely populated areas is not uncommon due to the occurrence of rich mineral deposits in some very mountainous, extremely dry, or frigid locations. In many cases, the developer must construct community facilities, including homes, schools, stores, and service facilities, and pay bonuses to induce workers to the project.

The resulting "company town" may have special problems, such as ineffective government, absence of pride of ownership, mental health problems relating to isolation and boredom, and high rates of worker turnover. These problems can be alleviated through creative programs,

[4/] See the bibliography section for a listing of social effects studies.

[5/] For a summary and analysis of the effects of coal and uranium development on several Rocky Mountain communities, see the extensive four-volume study: Energy from the West: A Progress Report of a Technology Assessment of Western Energy Resource Development. U.S. Environmental Protection Agency, 1977. Mountain West Research and Wyoming Research Association have prepared (1981-1982) a bibliography, field study, and assessment procedure for the Denver Office of the Bureau of Land Management. All deal with the social effects of coal development.

responsive management, and some measure of community self-government. The social and cultural life of established "one-industry" mining towns often differs from communities that are dominated by agriculture, state and county facilities, food processing, or tourism (Chapter 4).

Public sector capability. Individual cities, counties, and states differ in their ability to cope with growth. Some have planning departments, supplementary aid programs (technical or financial), and sufficient facilities and staff to accommodate reasonable growth, but other jurisdictions lack these services or are already committed to capacity. Some have excess capacity in such areas as schools, playgrounds, parks, social services, police and fire protection, or public utilities; while others have too little.

Established land-use patterns. Each geographic sector in the Rocky Mountain States tends to be dominated by two or three patterns of land use. Timber production and recreation, and cattle and wheat ranching are two common patterns. In some localities, mining, fruit growing, sheep raising, diversified farming, manufacturing, residential development, wilderness, or other land uses may surpass timber, cattle, or wheat in economic value.

Mining and mineral processing activities are more compatible with some of these activities than with others. New mineral projects are most acceptable to local people in areas where some form of mining is already widespread, where responsible industry operators have already won public support, and/or where existing activities are not disrupted by the addition of such operations. In many parts of the country, public resistance to mining is strong when lands are valued for other uses, such as outdoor recreation, agriculture, or wilderness.

Opportunity for advance planning. In the coal and metal mining industries, the critical details of development (location, mine size, work force requirements, etc.) are often known months or years before the site is occupied. This permits desired planning, construction, and expansion of community facilities and services (if funding can be obtained) before the peak population influx occurs.

In contrast, specific estimates of future petroleum development are difficult to project and obtain due to oil price fluctuations, industry secrecy, the multiplicity of specialized firms involved, the scattered nature of many petroleum deposits, and the speed with which these activities can be put in motion. Communities that realistically identify their future needs and mobilize their resources to meet them will experience the fewest difficulties.

Business sector capacity. Many local businesses in small Rocky Mountain and Great Plains communities are marginal or failing. Increased mechanization in agriculture and the consolidation of ranches have reduced the need for farm workers. Improved roads and vehicles encourage people to shop more often in larger cities and regional shopping centers. Thus, local businesses are often receptive to new industries which bring "outside" money into their communities. They welcome new payrolls and locally-offered contracts for construction or other services (even though major equipment or supplies are usually obtained from large industrial cities).

However, when a boom is too rapid, local businesses may have difficulty expanding their operations due to the decreased availability of both construction contractors and job applicants. Some communities experiencing development will eventually have sufficient consumer buying power to justify new businesses or services. Both local business volume and tax revenues will gradually increase. The private sector is likely to respond first, adding motels, restaurants, a car or mobile home dealership, or possibly a realty. In a year or two, tax revenues normally increase enough to permit increased street construction, some new utilities, additional schools or hospitals, and expanded social services, any of which would create additional local employment and income.

Secondary employment generated. Economic activities, such as mining, agriculture, construction, railroads, or federal employment, bring infusions of nonlocal capital into the economy. These are called "basic" or "primary" industries because community growth and economic prosperity tend to fluctuate with the size and health of these industries.

New payrolls and local purchases expand business activity and increase "nonbasic" or "secondary" employment. Local businesses increase their inventories, sometimes enlarge their premises, and new businesses are founded. The public service sector is also expanded to accommodate in-migrants.

The mathematical expression of the extent of new employment generated by basic industry is called an employment multiplier. This varies from less than one to three or higher, depending on how it is computed, how large an area is analyzed, and whatever other factors may operate to exaggerate or counteract the effects of increases in certain basic industries. Table 3-5 demonstrates one way to compute a rough employment multiplier using 1990 employment data for the State of Montana. Note how basic industry employment in Montana, in keeping with the national trend, is declining. Nonbasic employment, especially in service jobs, is increasing. Factors accounting for these changes include increased mechanization and automation in mining, logging, and manufacturing, and greater reliance on imports for both raw materials and factory goods.

The above approach is misleading when applied to individual local communities. Existing employees may simply handle more customers or patrons. Some earnings would be sent to workers' families in other cities. Some would be collected as state and federal taxes. Regional shopping centers in other cities would have increased sales. Economic benefits would thus be distributed far beyond the local zone. Individual county employment multipliers for Montana have been estimated at 1.5 to 2.5. This is an average of about one new local secondary job for each new basic job.[6/]

Local labor supply. As a rule, the proportion of local-hire workers is greatest when many workers with diverse skills are locally available (or few special skills are needed), the employer's operations are rapidly expanding, and there is a conscious effort to maximize local hire. Such workers can be hired whenever needed, already have housing, and need not be subsidized for living away from home.

[6/] Estimates based on State of Montana, Department of Labor and Industry data.

Table 3-5
Employment in Selected Montana Industries

Industry	1960	1970	1980	1990	% CHANGE 1960-1970	1970-1980	1980-1990
BASIC	Thousands of Employees						
Agriculture	39.0	36.1	32.0	31.3	-2.9	-4.1	-0.7
Mining	7.4	6.6	7.2	6.3	-0.8	0.6	-0.9
Metal	4.5	4.0	1.5	2.6	-0.5	-2.5	1.1
Coal	n/a	n/a	1.3	1.1	n/a	1.0	-0.2
Oil & Gas	2.2	1.8	3.3	1.7	-0.4	1.5	-1.6
Other Mining	0.7	0.8	1.1	0.8	0.1	0.3	-0.3
Manufacturing	20.4	23.9	23.6	22.4	3.5	-0.3	-1.2
Wood Products	7.3	8.2	8.5	8.2	0.9	0.3	-0.3
Primary Metals	3.8	4.7	2.4	1.2	0.9	-2.3	-1.2
Food Products	4.3	4.3	4.0	2.5	0.0	-0.3	-1.5
Other Mfg.	5.0	6.7	8.7	10.5	1.7	2.0	1.8
Railroad	9.0	6.6	7.1	3.6	-2.4	0.5	-3.5
Federal Govt., excluding military	9.9	11.9	13.0	13.9	2.0	1.1	0.9
Total Basic	85.7	85.1	82.9	77.5	-0.6	-2.2	-5.4
NONBASIC	Thousands of Employees						
Transportation, Communications, & Utilities excluding Railroad	10.0	10.8	16.3	16.5	0.8	5.5	0.2
Construction	11.0	11.0	15.6	10.4	0.0	4.6	5.2
Trade	40.5	48.3	74.9	78.4	7.8	26.6	3.5
Services*	30.0	41.8	68.7	88.9	11.8	26.9	22.2
State & Local Government	28.6	40.7	58.0	56.9	12.1	17.3	-1.1
Nonfarm Proprietors & Other	30.2	23.7	34.3	40**	-6.5	10.6	5.7
Total Nonbasic	150.3	176.3	267.8	291.1	26.0	91.5	23.3
TOTAL	236.0	261.4	350.7	368.6	25.4	89.3	17.9

Computation of 1990 employment multiplier:

Total/Basic = 368.6/77.5 = 4.8

This suggests that for every basic job which is created, total employment would increase by 4.8 jobs.

*Includes employment in Finance, Insurance, and Real Estate
**Estimated by author.

Source: Montana Dept. of Labor and Industry, Research & Analysis Bureau

Many of the new, locally-available jobs are not filled by the registered unemployed, but by people who change jobs or are not regularly in the labor market (e.g., ranchers, students, homemakers, and outsiders who hear of the new opportunities). Both the mining and construction industries pay well, encouraging many residents to switch jobs. Local wages rise as established businesses strive to retain their valued employees.

Established lifestyles. Often some local people regard new mining operations as threatening to pre-existing lifestyles. Examples include senior citizens who have selected a quiet, scenic, unhurried environment for retirement; cattle ranchers who wish to preserve their pastoral environment and family ranching tradition; tribal leaders who fear the continuing erosion of their ethnic heritage; and big-game hunters and backcountry outfitters who believe mining will have adverse effects on their activities.

Current economic conditions. A town or city with chronically high rates of unemployment or one where a major industry has just shut down can be expected to seek new industries. A prosperous community with a stable economic base; such as a combination of government facilities, light industry, and tourism could be much less receptive or even antagonistic to proposals for mines or plants in the vicinity.

Characteristics of Newcomers

The social and cultural characteristics of newcomers drawn to an area by a mineral project vary with the circumstances. Very isolated sites attract a disproportionate number of single and unaccompanied males. Conversely, if the area is well-populated and company policy maximizes local hire, newcomers may be mainly skilled workers, professionals, managers, and their families.

Construction contractors normally employ more transient and nonlocal workers than the mine or plant that follows. The personal characteristics of these workers (e.g., speech, dress, habits, and values) and the degree to which these patterns differ from local norms are both important. One might expect incoming miners to assimilate more readily in a community that is already accustomed to mining or to heavy manufacturing, compared to one supported by farming, cattle ranching, or a major public institution. Chapter 4 discusses the lifestyle of the traditional mining town.

OTHER CONSIDERATIONS

The lengthy list of variables above suggests that the analysis of economic and social changes and resulting community adaptation can be a complex procedure. The social scientist must further consider that:

1. Prior studies of the effects of certain types of exploration and development activities (e.g., hard rock minerals, oil and gas, industrial minerals, or synthetic fuels) are few in number and not readily available. Although some inferences may be made from studies focusing on other types of projects, a competent analysis may require extended field work to identify unique effects and mitigation needs.

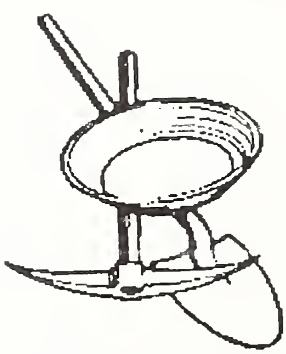
2. Most of the mineralized portions of the Rocky Mountain and Great Plains areas are unusually rural. In contrast, much of the remainder of the U.S. is more densely populated, land values are high, and land use is more intensive.

As recently as 1900, the U.S. was predominately rural. In 1990, 77.5 percent of Americans lived in 284 urban complexes (Metropolitan Statistical Areas and Consolidated Metropolitan Statistical Areas), almost all having 100,000 or more people. Most of the remaining inhabitants resided in smaller towns and cities. Only 2 percent lived on active farms or ranches. The emerging pattern has been the urban resident who looks to rural areas for food, raw materials, investment opportunities, and outdoor recreation. The recent counter-migration of urbanites to rural settings for work, recreation, or retirement has not changed this trend a great deal because most migrants want to retain their urban lifestyles and consumption patterns.

Thus, while mineral development projects may have the greatest impacts on rural populations, many outsiders have a vested interest in the success of a project proposal. When a project is approved, despite widespread local opposition, special emphasis should be given to identifying and avoiding the potential adverse effects that generated the opposition (Chapter 5).

3. Rural settings in the U.S. are increasingly influenced by urban areas (through television, schooling, agency programs, mass marketing, in-migration, and visits to urban centers) and are changing, whether or not local industrialization occurs. A new mine or plant may increase the rate of these changes, especially in isolated areas. Without careful study, it is difficult to determine how much cultural change may be attributed to a specific project.

4. Various special interest groups have a stake in National Forest System programs. These include organizations committed to resource conservation, environmental protection, wildlife, or resource development. When proposals for major changes or additions to agency programs are announced, the most concerned groups actively promote their interests through advertising, lobbying, legal action, or other available means. When a proposed change is important and controversial, new special interest groups often form to work for or against the action. In social analysis, the views of each special interest group must be weighed along with the needs and concerns of other publics who may be affected, but are not organized to further their individual or group interests.



CHAPTER 4:
Social and Economic Effects of Mineral Operations

The whole spectrum of social and environmental effects stemming from mining and related activities has social implications. Humans (1) define the need for minerals, (2) plan and develop mineral projects, (3) perceive both positive and negative consequences from such projects, and (4) determine what corrective measures should be taken. Mineral operations may affect a person's livelihood, living space, quality of community life, or environmental sensibilities.

It is difficult to visualize the total pattern of effects that could result from a major mineral project and to remain objective when evaluating these effects. Project data may be incomplete or subject to change. Often, the most readily available information is provided by special interest groups that favor or oppose the project.

Chapter 3 surveys the large number of interacting factors that account for the unique pattern of social and environmental effects at each mineral project site. The environmental analysis process can provide reasonably accurate insights into local sentiments, needs, and opportunities, an important first step in planning and developing a project that will earn broad community support. This process can also supply feedback on the merits and shortcomings of ongoing activities. People who initially favor or oppose a project sometimes change their minds about its desirability, depending on the way the project is planned and managed and the quality of public involvement.

OVERVIEW OF EFFECTS

A marked increase in mining activity has occurred in the western states since the mid-1970s. At first the main emphasis was fossil fuels--oil, gas, coal, and oil shale--but new metal and industrial mineral projects are now operational or under construction. Many undeveloped deposits with commercial potential exist in the National Forests of the Region (Chapter 1) and nation. Most of these minerals are available for leasing, sale, or claim under the mining laws (Chapter 3).

The 1981-82 and 1990-1991 recessions and a decade of depressed prices for petroleum and many minerals have decreased the momentum of mineral activities across the nation. Despite the recessions, the total net value of minerals production on National Forest System lands in the Northern Region has increased during this period; and exploration for new deposits continues, although at a reduced level.

One or more major mineral projects can profoundly affect a rural area, especially when the population is sparse and mining and minerals processing are locally regarded as inconsistent with established land-use patterns. The type and intensity of the effects vary considerably with the type, stage, and scale of mineral operations.

When mineral exploration is proposed and initiated, potentially affected individuals and groups

form impressions about the changes that eventual development would bring. These early impressions are shaped by news items in the local or regional press, data from special interest groups that favor or oppose the project, and rumors and speculations passed on by friends and neighbors (some of whom may have experienced similar projects). These expectations are periodically reformulated as more information becomes available at public meetings, in agency documents, and from personal observations of the events occurring locally. In short, local public impressions of social and environmental costs and benefits are derived largely from local evidence and may be revised as the situation changes.

In general, the economic benefits of a major mineral project on federal lands include lease rentals and royalties for certain minerals covered by the 1920 Minerals Leasing Act (chiefly oil, gas, coal, oil shale, sodium, and some other industrial chemicals), corporate profits, stockholder dividends, and increased tax revenues for all levels of government. At the local level, there are additional job opportunities and increased business activity.

The potential social costs of mineral development are more difficult to identify and measure, partly because they are less systematically researched and reported. They include the erosion of established lifestyles, local inflation for persons on fixed incomes, overburdened community facilities, increased personal stress, a greater incidence of anti-social behavior, reduced scenic and recreation options, and increased noise and pollution.

Figure 4-1 shows how a new basic industry creates jobs and increases local spending. These in turn generate additional public costs and revenues. When there is a significant population influx, local facilities and services must be expanded, and local institutions and lifestyles are affected. Well-planned and administered projects take these "external" effects into account.

Most prospecting efforts are short-lived, except when the presence of commercially valuable deposits is strongly suspected. In contrast, site development for a large project may require hundreds of employees for 2 or 3 years and the erection of temporary facilities to house them.

Production is usually the most stable and enduring phase, and most production workers become permanent local residents. The last stage, abandonment, is potentially the most serious in relatively rural locations, especially when it occurs on short notice. Other local employment options for jobless workers are few and usually pay less.

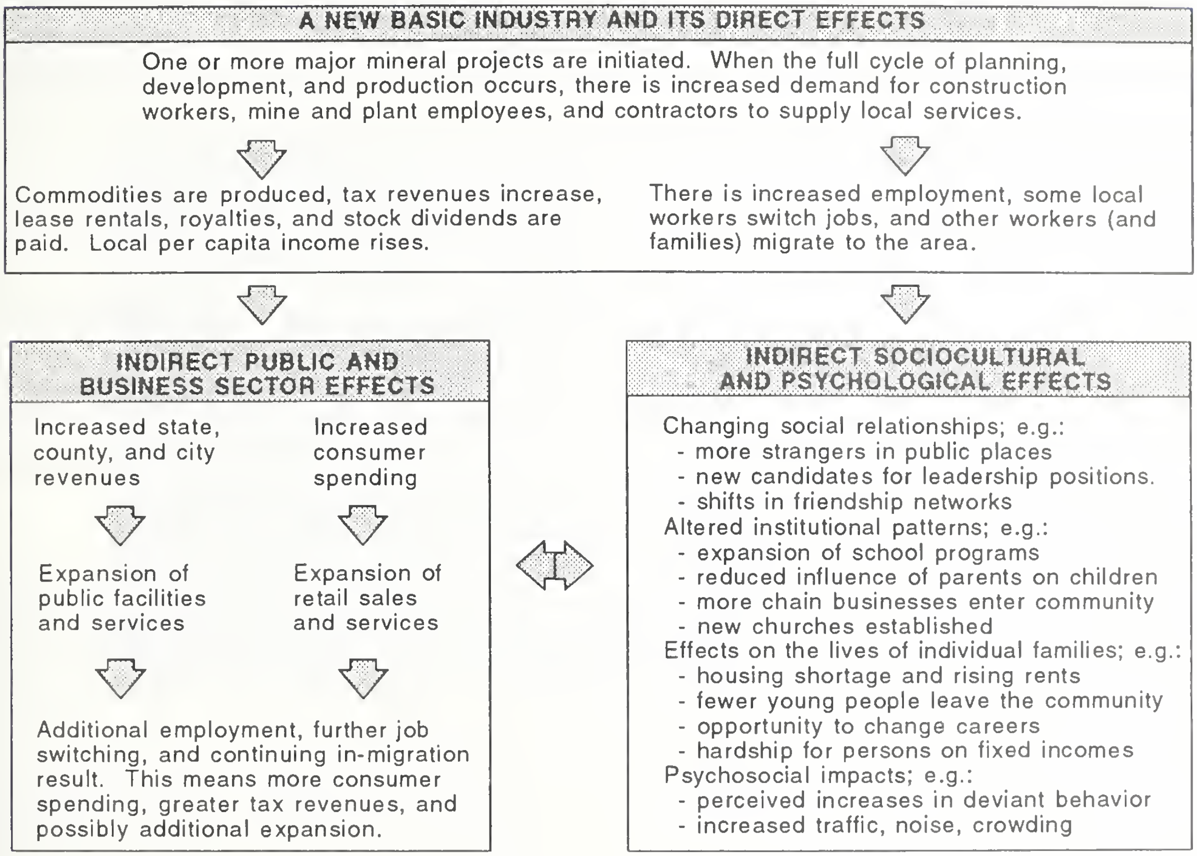
The social effects of each of these minerals operations are discussed in more detail in the following pages. Five case studies are included to provide illustrations of each phase of operations. Additional data sources are identified in the bibliography section of this document.

EXPLORATION

Preliminary mineral prospecting activity is usually scattered, intermittent, and low key. Few people are needed and little or no-surface disturbance is required if modern methods are properly

Figure 4-1

CHARACTERISTIC SOCIAL EFFECTS OF INDUSTRIAL DEVELOPMENT IN RURAL AREAS



used. The geologists and other specialists typically reside in motels and make field trips to evaluate and map the sites of greatest interest.

In regions of great mineral potential, including Montana, northern Idaho, and western North Dakota, prospecting is commonplace and increases in frequency when the mineral markets look favorable. Because few prospectors are likely to be present in any community at the same time, the social and economic effects of these operations are limited to minor increases in business activity, mainly in the travel-tourism sector.

When there is evidence of a large deposit with commercial potential, exploration intensifies. Several years of additional investigation may be necessary to gather enough data to justify a multimillion dollar investment decision. The social and economic effects of this exploration are governed by such factors as the type and size

of the mineral deposit, its accessibility (location, depth, existing roads), and the urgency attached to developing it. From one to several drills will be needed to determine the characteristics of an ore body or an oil reservoir and to locate its extremities. Roads, trails or helicopter landing sites are required to provide access, and hundreds of holes might be drilled over a square mile or more of land to determine the breadth and depth of a large ore body (Chapter 2).

Each drill requires a crew of from 2 to 25 persons (depending on the size of the drill), plus support personnel. Three shifts may be employed to permit 24-hour operations. Activities are usually confined to the warmer months but may be year-round in some "crash" exploration efforts. Anywhere from 10 to 150 persons might be involved in the summer exploration of an ore body or a promising oil-bearing formation.

Exploration generates more social and economic effects than prospecting because it involves more employees who may also spend months in a given location. But the scope of these effects is limited by the fact that many nonlocal workers bring their mobile home units with them, are in the area only part of the year, and are often unaccompanied by families. Up to half of the workers may be local-hire and require no additional facilities and services.

One or a combination of methods may be used to house, transport, and supply exploration employees. They may live nearby in mobile units or in apartments in a neighboring town and drive to work. Shifts of workers may be ferried in from more distant places by helicopter. An on-site tent camp may be established, permitting workers to remain there for long periods, supported by weekly helicopter deliveries of food and supplies.

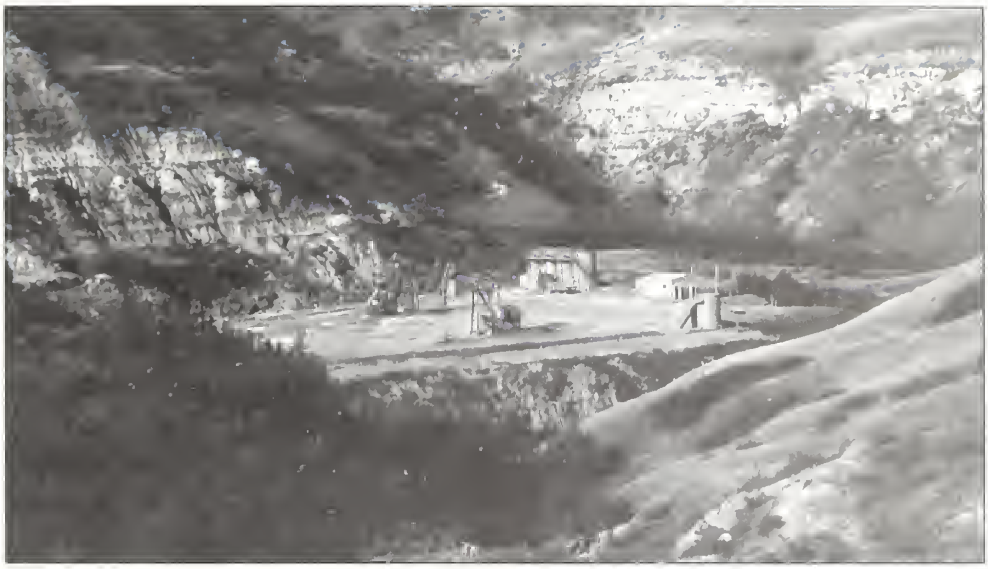
The major effects of exploration will be increased business volume for motels, restaurants, and gas stations, plus some temporary employment for local residents. At this stage most local residents and special interest groups become aware of potential mineral development and production in their vicinity. The intensity of their reaction varies from one project to another depending on factors; such as local economic conditions, existing land uses, local lifestyles and outdoor preferences, the ecological sensitivity of the exploration site, and the way in which the proposed activity is designed and presented to the public.

In the majority of cases (Chapter 2), systematic drilling will reveal that the ore body is not large or concentrated enough to be commercially feasible, and operations will cease. When the deposit is submarginal (almost economic enough to extract), operations may be suspended but resumed when higher prices, technological innovations, or new support facilities make mining feasible.

In general, no significant expansion of local facilities and services is necessary for prospecting and exploration activities. The existing infrastructure usually can accommodate them. Exceptions occur either when a large project is initiated in a very remote area, when several companies decide to explore a given location during the same season, or when exploration is in addition to other new projects or recreation use that already strain an area's capacity to house and supply transient people.

CASE STUDY 1

Oil and Gas Exploration and Development
Little Missouri National Grasslands
North Dakota



Oil was discovered in northwestern North Dakota in 1951 and scattered field development followed. Production was modest by Texas standards and was declining by 1960 due to the competition of cheap crude oil imports from the Persian Gulf and other overseas locations.

Energy Crisis Spurs Exploration

In 1973 the Organization of Petroleum Exporting Countries (OPEC), which supplied the majority of the world's imported oil, began to raise prices. By 1979 a barrel of crude oil which cost $3.39 in 1972 had quadrupled in price to $12.64. Following the deregulation of domestic oil prices in the U.S., oil prices more than doubled again to $31.77 per barrel in 1981.

Then, as now, oil was the industrial world's most critical energy source, a vital fuel for heating, for powering most types of vehicles and heavy machinery, and for the production of electrical power. It was also used as a raw material in manufacturing hundreds of plastics, refined oils, chemicals, and other compounds.

The dramatic price increase stimulated a domestic boom in oil and gas exploration in areas with known or suspected potential but once regarded as uneconomic to develop. The boom was also

encouraged by federal efforts to increase the nation's energy self-sufficiency and by new theories about the existence of oil deposits in the Rocky Mountain Overthrust Belt. In addition, recent technological advances made exploration and well drilling more feasible in areas with rough terrain, cold winters, and deep-seated oil-bearing formations.

A flurry of oil and gas operations occurred on public and private lands in and near the Rocky Mountains from Canada to New Mexico. Production was increased in some older fields and seismic exploration and exploratory well drilling operations were initiated in many new locations. By 1978 an oil and gas boom was well underway in various rural locations in Montana, North Dakota, Wyoming, and Utah. Cumulative social and environmental effects became increasingly apparent. When road construction, field development, and pipeline installation followed, these effects intensified and the Forest Service increased its efforts to understand and to mitigate adverse impacts.

Social and Economic Setting

The Little Missouri National Grasslands of North Dakota consists of two million acres of dry rolling prairies and severely eroded "badlands" extending for 100 miles just east of the Montana border. These Grasslands are part of the National Forest System, administered by the Custer National Forest through Ranger Stations located in Watford City and Dickinson. The federal Grasslands are intermingled with lands managed by the State of North Dakota, Corps of Engineers, Bureau of Land Management, National Park Service, railroad companies, and private ranchers.

Most of the federal acreage was acquired at the end of the Great Depression, following 2 years of devastating drought and wind erosion that bankrupted many farmers and ranchers. The area is divided into two planning units, a central Badlands unit that surrounds the two segments of the Theodore Roosevelt National Park, and an outer Rolling Prairie unit. No sizable community exists within the area, so residents, tourists, and petroleum industry personnel depend on neighboring cities, chiefly Dickinson, Watford City, Williston (ND), and Sidney (MT), for shopping and services.

Prior to the petroleum boom, the Forest Service managed these lands under 1974 and 1975 Forest unit plans that provided for multiple uses, including grazing allotments, outdoor recreation, and leases for petroleum exploration and development. Federal leases were issued with stipulations to protect surface resources, and adjacent state, corporate, and other private lands were also open to leasing. Several oil firms obtained petroleum leases on both federal and private lands and began the search for oil and gas.

Exploration and field development expanded very rapidly throughout the seven counties encompassing the National Grasslands because of the simultaneous operations of so many oil companies and their contractors. Hundreds of square miles were explored because the chance of a major discovery at any one site is very small.

Few local governments, agencies, and other service organizations anticipated or were prepared to cope with the magnitude of changes that occurred.

The first wave of exploration and drilling crews in the Grasslands was a mix of experienced specialists from other oil regions and locally-hired helpers. The outsiders tended to be fairly young males who were unmarried or unaccompanied by their families. The road and construction contractors they hired were more often local, when available, but sometimes from other oil producing areas; such as Texas, Oklahoma, and California.

Social Effects of Exploration

Between 1977 and 1984, this combination of exploration and field development ultimately involved several major petroleum companies and 50-100 contractors. The influx of people and dollars produced an economic boom and related social impacts in the affected counties of western North Dakota and Richland County in Montana. Most existing businesses prospered and new firms were established.

Local motels were booked far in advance and tourists were displaced. Available homes were sold, rentals were occupied, and new housing subdivisions were developed. Land values, home prices, and construction costs rose. Drought-plagued ranchers and farmers found petroleum-related employment, and many retail sales and service workers switched jobs for better pay. The boom reversed the pattern of net population loss in some of these rural counties and slowed the decline in others.

Case Study 4 discusses the social and economic effects of the boom and subsequent phasedown in more detail. In general, local businesses, including motels, retail sales outlets, travelers' services, and contractors, welcomed the increased volume of business. Many local residents, while apprehensive about all of the changes occurring, found favor with the increased range of consumer goods and services.

Some ranchers profited from oil leases and royalties or by contracting their services to oil firms. Other ranchers were disturbed by the noise, dust, risk of gas emissions, and loss of privacy. Persons on fixed incomes saw their cost of living rise and also perceived a loss in privacy and personal security. Cities, counties, school districts, and public and private service organizations were sometimes overwhelmed by the rapid increase in the demand for their services; such as additional streets, utilities, schooling, recreation, medical care, law enforcement, and social services. Conservationists and recreationists were dismayed by new roads and drill pads in the once-remote and scenic Badlands and apparent impacts on wildlife and vegetation. Visiting tourists, commercial travelers, and government officials were frustrated by the need to book weeks in advance to secure a motel room.

Clearly, many of the problems stemming from rapid oil and gas development could have been avoided or reduced through cooperative multi-agency planning. Measures were needed to coordinate the activities of different firms and their contractors and to ensure gradual, manageable development. Incremental exploration and development would have extended the period of economic growth and eased the burden on public

and commercial services. Cooperation to minimize duplication of exploration, drilling, roads, pipelines, and other facilities would greatly reduce environmental impacts. The Custer National Forest has developed procedures to control the pace of future development, and the State of North Dakota has also responded to this need. When development is gradual, local governments and institutions have time to adapt; economic and population growth are moderate and more stable; and a phasedown is less traumatic. The substantial decline in oil prices beginning in 1983 also reduced pressure to develop. By 1986 the price for crude oil had dropped to less than half of the 1981 price, and many domestic wells became unprofitable. The results of this decline are summarized later in this chapter (Case Study 4). If sharp increases in petroleum prices stimulate another boom in western North Dakota, responsible state and federal agencies will be in a better position to channel its pace and direction and to mitigate unwanted social and environmental effects.

SITE DEVELOPMENT

In the mining and processing of minerals and fossil fuels, site development is often the most labor-intensive phase of operations. It may also overlap with production (Figure 2-7), thereby increasing population impacts. Hundreds, or occasionally thousands, of construction workers can seriously overburden rural counties and towns, particularly when the firms involved fail to provide any of the housing and services their new employees require.

When commercial quantities of oil and gas are discovered, more drilling crews are brought in to develop a field. Additional crews, usually contracted for specific purposes, are needed to construct roads, drill pads, mud pits, pipelines, and other facilities. A field of 10-100 wells will require hundreds of workers to develop, and the promise of extended employment will encourage many nonlocal workers to bring in their families and look for more permanent housing. This increases both local consumer spending and the demand for public services.

When expansion of community facilities is necessary and feasible, the process is often unavoidably gradual and incremental, and thus too slow to benefit the construction workforce. Furthermore, it is unwise for local governments or businesses to extend their permanent facilities and services beyond the capacity needed to serve the smaller but long-term mine or plant labor force. For this reason , some responsible mining firms provide for the needs of their construction workers by setting up temporary camps near the site for mobile or modular housing and providing group facilities for dining and recreation.

The unique characteristics of most nonlocal construction workers both simplify and complicate the task of accommodating them. Typically they differ from established residents in several respects.

1. The majority are from outside of the area. Most nonlocals live too far away to commute daily. They seek housing within commuting distance, which for most workers is less than 50 miles each way.[1]

2. About 25 percent of all nonlocal construction workers are unmarried or separated, and another 25 percent are married but not accompanied by their families.[2] As a result, worker housing needs differ somewhat from the permanent force that will arrive later, largely married and with families.

3. Family size averages about 3.5 persons per married nonlocal worker with family present. This computes to about 2.2 persons for each nonlocal worker hired. But locally, this influx will vary considerably from one site to another depending on:

a. the availability of appropriately skilled local workers and the developer's need for them. Of 26 projects analyzed by Mountain West Research, local workers were 11 to 87 percent of all workers, with 30 to 60 percent the most usual range.[3]

b. the percentage of nonlocal workers accompanied by their families. This varies with the distance to the project, the availability of housing and community services, the age of the children,

[1] Leholm, Arlen, F. Larry Leistritz and James Wieland. Profile of Electric Power Plant Work Force. Fargo: North Dakota State University Experiment Station, 1976.

[2] Mountain West Research, Billings, Montana. Construction Worker Survey, 1977.

[3] Ibid.

the degree of family integration, and the expected duration of employment.

4. At sites in very rural locations, construction workers tend to be 95-100 percent male and disproportionately young and single. In the absence of established recreational programs, effective law enforcement, and the normal constraints imposed by friends, relatives, and neighbors, the incidence of anti-social behavior sometimes exceeds regional norms, especially in such incidents as intoxication, fighting, burglary, traffic violations, poaching, vandalism, and litter.

5. Construction workers are relatively well paid (Table 4-1) and may earn higher wages, overtime pay, and other compensation at hardship locations. They may be able to pay above-average rents and prices for goods and services available in local communities, thereby inflating prices. Construction work frequently attracts local employees from other fields; e.g., farm labor, retail sales, local building or repair firms, or public services.

6. When a project is completed, some workers will want to remain in the area. When permanent mine or plant jobs are not available, the worker will seek other employment, unemployment insurance benefits, or county assistance.

The construction phase of project development is usually more impactive socially and economically than exploration or production. The work force is often larger than the subsequent operating force and portions of the two groups may coexist for several months. The construction

Table 4-1
Average Work Week and Income in Montana, October 1991

Industry	Hourly Earnings	Hours Worked	Weekly Earnings
Manufacturing	11.82	41	479
Mining	14.61	41	596
Construction	14.64	39	568
Transportation, Utilities	13.48	36	479
Retail	6.69	35	187
Finance, Ins., Real Estate	8.82	36	318
Services	8.54	31	260
Average Private Sector	9.58	32	310

Source: Montana Department of Labor and Industry, Research and Analysis Bureau, Montana Employment and Labor Force Trends, 4th Quarter 1991.

force may increase rapidly at a time when the community is ill-equipped to meet its housing and service needs. The negative consequences of rapid development are most evident under such conditions. Increased rates of conventional crime, spouse and child abuse, divorce, suicide, job turnover, alcohol abuse, and mental health referrals suggest high levels of personal stress, especially for newcomers who lack the personal and institutional supports of established residents.

The combination of such factors as inadequate housing, limited recreational options, difficulty establishing credit, local hostility toward construction workers, and the bleakness of many rapid-growth communities is sufficient to demoralize residents and motivate some newcomers to move elsewhere.

The social responsiveness of a mineral project can be increased through careful design and implementation. First, identify potential problems and opportunities by reviewing the experiences of similar projects and by considering unique elements of the present situation. Then encourage continuing consultation among the developer and major contractors, the concerned state and federal resource agencies, local governments, and affected landowners to help ensure that the environment is adequately protected and that local communities are in a position to receive discernible benefits and to manage the social effects generated by the project.

It is usually more expensive to design and to construct a model facility than a makeshift operation, but there are potential long-term benefits for all concerned. A well-designed plant is attractive, provides a relatively safe and comfortable work place, and controls pollution. A program emphasizing local hire, especially in the production phase, would reduce local unemployment, avoid impacts on schools and housing, and provide a stable, responsible work force. There would be increased public support for the project and a reduced likelihood of costly lawsuits because of poor management practices, environmental degradation, and neglect. Evidence from a case study of the Troy, Montana, experience supports this contention.

CASE STUDY 2

Site Development and Production
ASARCO Copper /Silver Mine
Troy, Montana

The ASARCO-Troy project is a copper-silver mine located on National Forest lands in rural Lincoln County in mountainous northwestern Montana. The mine and ore concentrator are located 20 miles south of Troy (population: 953), and about 30 miles southwest of Libby (2532), the county seat.

Nature of the Project

A mine and plant site were constructed during 1979-1981, following a decade of intermittent exploration. The prefabricated concrete and steel structures house a crusher, concentrator, connecting conveyor belts, offices and shower rooms, a workshop, storage tanks for water and fuel, a power substation, a sewage plant, a thickening pool, and fire control installations (Figure 2-8). The plant parking lot is approached via seven miles of paved road from state Highway 56. An existing powerline has been upgraded, and six miles of new line have been constructed to bring 115,000 volt current to the facility.

The mile-long subsurface ore body has been accessed by a large entrance ramp that can accommodate oversized trucks and drilling machines. There are also three ventilation adits and a powerful exhaust system. Some of the 200,000 tons of material removed to open the mine were used in plant site construction.

During the construction period, the work force peaked at 250 and then declined to about 150 in the summer of 1981, at which time a portion of the operating force began limited production. By March 1982 the plant work force of 330 was complete and full-scale production was underway.

The mine operates continuously, requiring three shifts daily and a skeleton force on weekends. Using the room-and-pillar method (Chapter 2), the ore is broken loose and passes through the mine crusher. It is carried via conveyor belt to the concentrator, where it is reduced to a fine powder that is 33 percent copper and contains about 70 ounces of silver per ton. The concentrate is transported by truck to Troy and transferred to freight cars for shipment to a company smelter in El Paso, Texas.

Concentrator wastes are thickened by removing excess water and piped six miles downhill to a 265-acre tailings enclosure. Wastes may also be stored in vacated portions of the mine at a later date.

The projected life of the ore body is 19 years, unless additional deposits are discovered in the vicinity. When the site is abandoned, the company is committed to reclamation by (1) replacing topsoil on the site, waste dumps, and tailings pond, (2) reseeding with a mixture of native vegetation, and (3) controlling drainage and thus preventing toxic runoff and erosion.[4/] Discovery of new deposits may extend the life of the project.

Social Effects of Development

Local impressions of the social and economic effects of the project were obtained from several Forest personnel and a non-random sample of 40 residents of Lincoln and Sanders Counties. These included elected and appointed officials, businessmen, educators, representatives of special interest groups, law enforcement personnel, and plant employees.

Almost all respondents were supportive of the project, including some who offered criticisms. Several people said they were initially apprehensive about the project's social or environmental effects, but their concerns were alleviated by the company's positive approach to planning and development. Those who remained critical of the project either focused on specific situations or expressed concern about the cumulative effects of additional mineral development activities. The general impressions gained from the interviews and site visit are summarized here, recognizing that this is only a partial sketch of the project's social effects.

1. The project is well-designed and landscaped. The plant, entrance road, and tailings enclosure occupy about one square mile of land. There are few eyesores; such as visible waste dumps, abandoned materials, or eroded land surface. Located on a dead-end road and surrounded by trees, the mine and plant are unobtrusive. The tailings enclosure on the valley floor is much more conspicuous. The large U-shaped earth dam which impounds the continually accumulating tailings is difficult to camouflage. The pond will be reclaimed as it is filled by covering it with a layer of topsoil and planting a mixture of trees and grasses.

2. Opportunities for local employment increased. Since the completion of the Libby Dam about 1971, Lincoln County has been plagued by

[4/] The project EIS, prepared by the Kootenai National Forest and the Montana Department of State Lands, 1978, provides further details.

high rates of unemployment, generally 12-14 percent. The 1980-82 slump in the wood products and construction industries aggravated this situation.

The project's initial work force of 330 included: mine (31%), concentrator (26%), maintenance (27%), office (15%), and security (1%) personnel. The lowest wage paid at the mine was $10.15 (grade 1 worker, day shift, 1981). Overall earnings plus benefits exceeded most other local opportunities and compared favorably with mining operations in other states.

As a result of the company's local hire policy, 96 percent of the newly-hired employees were recruited from Troy, Libby, and other locations within commuting distance. Only 17 supervisory personnel were transferred to the plant from other locations to train local workers and to initiate mine and plant operations. This has increased the economic stability of many local families and reduced the number of defaults on home and auto loans.

Local hiring encouraged considerable job switching, as unemployed loggers and mill workers, seasonal Forest Service employees, local government workers, and underemployed office and sales personnel sought to improve their income. One Troy resident said "everyone moved up a notch." Official local unemployment in Lincoln County has been among the highest in the state since the completion of the Libby Dam and related construction a decade ago. Project employment has helped the situation, but did not reduce the unemployment rate (up to 35% in March 1982) in the face of increased layoffs in the lumber industry and federal work forces.

The emphasis on local hire discouraged extensive in-migration, but most project employees are spending more money than before. Since the completion of construction, existing businesses and public services are able to meet the increased demand without much additional staffing because the economy was very depressed and most of them were operating at below peak capacity. As a result, there has not been a substantial amount of secondary employment generated by the project.

3. Local earnings and revenues increased. In 1981 ASARCO-Troy provided an $8 million local payroll, made substantial local purchases, and paid $5 million in federal, state, and local taxes.[5/]

At least two small and one 90-unit housing areas are being developed or expanded, due in part to the mine project. The absence of planning and zoning regulations could contribute to future problems in rural portions of Lincoln and Sanders Counties if additional growth occurred. Too many simultaneous construction and mining activities could create undesirable lifestyle impacts for residents and recreationists.

4. The project strengthened and diversified the economy. Although there was a vermiculite mine and increasing tourism, wood products manufacturing was the dominant basic industry in Lincoln and Sanders Counties. The economy was very sensitive to the effects of seasonal layoffs and annual fluctuations in the demand for lumber. The mine, an all-season industry with a different product, adds to the stability of the economy and increases local business activity.

[5/] ASARCO personnel office data.

More people now have an assured annual income and are able to commit themselves to installment purchases; such as homes, cars, and appliances.

5. The people of Troy benefited from the project. The suspension or reduction of most logging operations, the primary source of Troy's basic income, had serious social and economic effects. Several small businessmen serving the Troy market area say they have managed to stay in business because of increased sales to project employees. A few businesses have been started or have occupied new premises.

The value of the plant complex and its production more than doubled the assessed valuation of the unified Troy School District. New project employees account for only 4 percent of the enrollment and include children of returning residents as well as newcomers to the area. Company employees play an active role in the Troy government and in voluntary group work.

Of the project's facilities, only the loading dock is within the Troy city limits, and it is on railroad property. Some respondents think the city incurred some additional expenses due to increased traffic and more frequent use of city services but has not had equivalent revenue increases. The city's limited sewer capacity restricts building within the city and precludes the property tax revenues this would generate.

6. The project did not significantly impact county and city facilities and services. This is because Lincoln County's population decreased during the 1970s (1.7%), the school-age population declined at an even greater rate, and most project workers were hired from the existing population. Some school enrollments, including Libby's, continued to decline but at a reduced rate, diminishing the need to curtail programs or staffing. Most city and county agencies report only minor changes in the demand for services. One exception was the manageable increase (perhaps 50-100 families) in social services case loads in Lincoln and Sanders Counties due to in-migrant workers who failed to obtain mine employment.

The company built its own mine entrance road and does not strain the existing county roads and facilities, yet it contributes tax dollars based on the value of its holdings and the value of the metal produced. Company employees also pay county-city property taxes, which are increasing because some employees are purchasing new or larger homes.

City and county law enforcement officers say that virtually no increases in the type or frequency of law violations may be attributed to the project. They mentioned only the need to clarify local police authority on the ASARCO premises.

7. The company makes local purchases. Local firms have successfully contracted to supply the project with commodities and services, including sand and gravel, light trucks, vehicle parts, office machines, furniture, drilling services, repair work, chartered helicopters, and fuel. At least some sales have resulted from local businesses taking the initiative in securing contracts.

8. The company demonstrates concern for its employees and seeks a positive public image. In 1981 the company sponsored a mine and plant open house with a luncheon for employees and their guests. There is a company-supported

comprehensive insurance plan for employees and their families. The company provides bus service at low rates from Libby and Troy to the plant, supplies speakers to school and community groups, and permits mine field trips. ASARCO trained almost all of the local-hire mine workers and many of the concentrator employees. There are opportunities for promotion; i.e., 12 workers hired in 1981 were soon foremen or shift bosses. Most mine and plant workers are fairly young males who have some prior experience with trucks and machinery. They are said to learn the required additional skills quickly.

9. No major environmental problems were identified at the time of the study. Most respondents who commented on the subject had noted no serious environmental impacts. Not all respondents were this optimistic. A few expressed concern about eventual seepage of toxic substances from the mine or tailings pond which could degrade the high water quality of the area. Some interviewees said the company was reluctant to take all necessary measures to protect water quality, but ultimately did.

10. Local lifestyles have been relatively unaffected. Both established residents and newcomers to Lincoln County tend to be very attached to the area because of its natural amenities. This part of Montana is unusually rugged and scenic, with numerous pristine streams and lakes, lush vegetation, cool summers, and mild winters. There are unusually abundant opportunities for outdoor recreation. It was alleged that unemployment is persistently high in the county because some residents are not willing to leave, even when there is no available employment.

PRODUCTION

Production is ordinarily the most stable and enduring phase of mineral and petroleum operations. Mineral production includes extracting, crushing, and transporting ores to concentrators, removing their mineral compounds, and then smelting and refining the concentrates to produce metals. Petroleum production involves pumping oil or gas from wells, removing water or impurities, and transporting the crude oil or gas to refiners or markets by truck, train, or pipeline.

Mining, including nonfuel minerals, coal, and petroleum, was almost a $4 billion industry in the four states of the Northern Region in 1987 (Table 4-2). The mining industry employed 14,200 people in extracting activities, with a payroll of $417 million (Table 4-3). Thousands of additional workers were engaged in smelting, refining, and transporting these raw materials.

Local Economic Effects

Major new mine or plant facilities usually are planned, financed, and managed by nonlocal interests. Typically, a large corporation decides to expand or diversify its operation in an effort to increase its return to investors. When the project is announced, it usually receives some local support because of anticipated increases in area employment, business activity, and tax revenues.

Extracting and processing a large ore body creates 200 to 500 or more mine and concentrator jobs over a 20-to 50-year period. The construction of a smelter or refinery provides employment for additional hundreds of workers. The long-term trend toward open-pit mining and the mechanization of many extracting and hauling operations have reduced work force and/or time requirements for removing a given quantity of ore.

Table 4-2
Value of Mineral Production (in $1,000) in the Northern Region States, All Lands, 1990

State	Nonfuel Minerals	Crude Oil (1988)	Natural Gas (1988)	Coal (1990)	Total	% of State Total: Non-fuel	% of State Total: O & G
Idaho	344,200	-	-	-	344,200	100	0
Montana	573,800	319,000	88,000	813,000	1,793,800	32	23
N. Dakota	20,400	580,000	115,000	628,000	1,343,400	2	52
S. Dakota	321,600	NA	NA	-	321,600	100	0
Totals	1,260,000	899,000	203,000	1,441,000	3,803,000		

NA = Not available; presumed to be relatively minor in 1988.

Source: Montana Oil Journal, Statistical Abstract of the U.S., 1990, Bureau of Mines, State Mineral Summaries, 1991, and National Coal Association, Facts About Coal, 1991.

Table 4-3
Mining Employment in the Northern Region States, 1987

State	No. of Employees	No. of Firms	Mining Payroll ($1,000,000)
Idaho	2,400	97	71.6
Montana	5,700	373	163.4
N. Dakota	4,000	296	119.5
S. Dakota	2,100	75	62.3
Totals	14,200	841	416.8

Source: U.S. Dept. of Commerce, Bureau of the Census, Mineral Industry Survey, 1987.

When an oilfield is fully developed, relatively few employees are needed to maintain pumps, equipment, and facilities. Sometimes these jobs last 20-50 years and local communities have a dependable source of consumer-spending and tax revenues.

The addition of a substantial new payroll to the economic base in rural western communities normally results in population growth because only a portion of the work force is hired locally. The extent of local hire depends on company policy and the size, skills, and availability of local job candidates (Chapter 3). Usually some unemployed local workers are hired, employed-locals switch jobs to increase their earnings, and some worker in-migration occurs. A cadre of managerial, professional, and skilled employees is transferred to the project to provide leadership, and other newcomers arrive spontaneously in search of employment.

Most of the new payroll is spent for consumer goods and services or collected in taxes. There is increased business activity, both locally and in regional shopping centers. Previously successful businesses usually expand their operations, and some marginal enterprises now prosper. But at least a few other businesses are likely to be displaced by local outlets of national or regional chain stores and restaurants. A second round of employment is thus generated, and additional newcomers arrive to fill some of these positions. Other jobs are filled by previously unemployed persons, including homemakers, students, and unskilled workers who were unable to obtain mine or plant employment.

Affected counties and communities, especially in sparsely populated areas, may find it necessary to add school classrooms, to extend public utilities, to enlarge police and fire departments, to construct roads and streets, and to add new services. This is ultimately feasible because of increasing property tax revenues, but hardships occur due to a 2- or 3-year lag between the need for such expansion and the eventual receipt of additional taxes, grants, or growth-related funding increases from state and federal agencies.

The gap between expanding needs and delayed funding may be shortened by encouraging the developer to pay property taxes in advance, and by floating loans or securing special impact aid grants from public or private sources. Several months are required to obtain funding by these means and the planning and construction of new facilities usually takes another year or two, depending on their type, scale, and complexity.

Both the property value of a new mine or plant installation and its production are taxable. Sales, income, and excise tax collections will increase because of greater employee earnings and consumer expenditures.

The revenues from coal are greatly enhanced by the severance tax collected in each state that has one. (A high severance tax in a particular state can, however, cause a shift in activities to other areas.) There is no tax of comparable magnitude on metal mining, and none is likely in the near future because of poor market conditions for many domestically produced metals.

The potential economic gains from metals and industrial mineral projects are nevertheless great. They include tax revenues for all levels of government and a wide variety of benefits for the private sector. Table 4-4 illustrates the range of possibilities.

Population Growth and Social Changes

A major mine, oilfield, or processing plant may operate continuously for two or three generations. Its presence in a relatively rural area is imposing and influences the social organization, outlook, and lifestyles of nearby communities. The magnitude of the impacts varies with the size of the facility, hiring policies, the characteristics of the affected communities and other variables described in Chapter 3.

Population changes. Many researchers believe population change is the single most important factor affecting community well-being, contributing to prosperity and infrastructure improvements in some instances and to economic instability, social disorganization, and adverse social conditions in others. In one-industry mining towns, population shifts usually relate to changing labor force requirements in the mines or processing plants.

Excessively rapid growth puts severe burdens on local governments, schools, and utilities, and increases stress among affected residents. Steady but gradual growth contributes to local business prosperity and additional jobs in secondary industries. Loss of population may result in a depressed economy, business closures, and further population decline.

It is the <u>rate</u> of population change rather than the <u>number</u> of incoming residents that is crucial. Normally a city of 10,000 can absorb or lose a given number of people much more readily than a smaller community of 1,000. That is, if 90 workers and their families move in, the burden on the city's housing capacity, utilities, businesses, and public services is increased by 2-3 percent rather than by 20-30 percent.

The culture of a larger city is also more complex. Social class, ethnic, and occupational variations in lifestyle are experienced daily and the presence of strangers is routine. Formal law enforcement supplements the informal social controls that usually suffice in rural areas. The arrival of

Table 4-4
Potential Revenues and Income from Minerals Development

GOVERNMENT REVENUES

Federal Level:

Corporate income taxes on taxable income.
Individual income taxes on additional basic and secondary wages, salaries, and dividends that are paid.
Federal excise tax increases (on sales of gasoline, alcohol, and other taxed items).
Federal agency collections:
- Bureau of Land Management fees for prospecting, filing claims and lease applications, issuing licenses, and patenting claims.
- Minerals Management Service revenues from federal leases.
- Forest Service special-use fees for off-site roads, pipelines, or other facilities.

Lease rentals and royalties for coal and other leasable minerals (Chapter 1).
Lease rentals and royalties for all minerals extracted from acquired lands.
Fees and market prices for common varieties (mineral materials).
Coal mine reclamation fees paid to the Department of the Interior (PL 95-87, Sec. 402 (a)).

State Revenues:

Corporate and individual income taxes (South Dakota excepted).
Sales taxes (Montana excepted).
Excise taxes on gasoline, tobacco, liquor and utilities.
Motor vehicle and other licenses and fees.
Redistribution of agency collections from filing fees and special-use permits.
Property taxes.
Gross receipts taxes.
Increased lottery and betting receipts in Idaho and South Dakota.
Federal transfer payments to states (social programs, impact aid, etc.).
Severance taxes on metal and coal, when applicable.
Liquor store and public utility sales increases.
Leasing rentals from state lands.

Local Revenues:

County real estate receipts increase with property values.
County personal property tax receipts increase.
Increase in licenses and permits issued, fees collected.
Forest Service distributes 25 percent of surface-use fees collected to counties with National Forest lands.

Table 4-4 (continued)
Potential Revenues and Income from Minerals Development

Local Revenues: (cont)

Redistribution of National Forest minerals revenue payments by state:
- Montana: Payments for education are made to counties (whether or not oil is produced using the equalization formula.
- North Dakota: 25 percent of revenue (from acquired lands) is paid directly to the counties where production occurs.

Redistribution of a portion of the state coal and petroleum severance taxes to local governments.
Municipal utility receipts (water, sewer, buses, etc.).
Street and sewer assessments.
City and county income taxes, when applicable.

PRIVATE ECONOMIC BENEFITS

National Level:

Increased business activity; e.g., the manufacture and sale of machinery and equipment for mining and processing minerals, vehicles, pipes, building materials, and plant and mine supplies.
Additional demand for long-distance rail, truck, water, and/or pipeline transport, household moving, consultants, and other services.
Expanded employment in the above industries.
Greater availability of domestic sources of minerals and possible reductions in imports.
Dividends to investors.

Regional Level:

Increased business activity, including seismic exploration, contract drilling, site development, and the construction of roads, pipelines, and power facilities. For regional market centers, increases in wholesale and retail sales, and an expanded demand for business and personal services.
Convenient sources of raw materials for regional processing plants.
Increased employment with drilling firms, road and site contractors, and mine service companies. More jobs in a variety of secondary fields; e.g., in medical services, education, retail sales and services, business and residential construction, transportation and communication, environmental protection, and other fields.

Local Level:

Increased business activity for local stores, banks, service firms, utilities, bars and restaurants, motels, etc.
Expanded employment opportunities in both the mining industry and various support occupations, including teaching, medical services, social programs, and law enforcement.
Improved market for real estate, new houses, mobile homes, and rental housing.

industrial workers is a less dramatic event in a city than in a small town, and many more newcomers are required to "outnumber" the older residents and thus significantly affect the course of social change.

Excepting Northern Idaho, the average annual growth rate in most Northern Region locations is under 2 percent, requiring 40 years or more for the population to double. However, an increase of 15 percent annually would double the population in just 5 years, greatly reducing the time available for adapting facilities, expanding revenues, building homes, extending services, and adjusting traditions and attitudes. Generally, the more rapid the growth, the more problems that vex both newcomers and oldtimers and the greater schism between them.

When development-related population influx occurs, the affected towns and cities grow at different rates. This situation sometimes perplexes local planners, who wish to estimate where newcomers will live. Such information is essential for public and private efforts to prepare for the influx. Advance preparations can markedly reduce the disappointment and stress that result when in-migrants are unable to find adequate housing and community services.

Several considerations influence residence selection, and individuals and families differ in the importance they assign to each. Housing options are often extremely limited, and many persons and families do not find what they want or need. Eight criteria utilized when two or more options exist are:

1. The time required to travel daily from home to work. Very few permanent residents are willing to drive more than 40 minutes each way.

2. The availability of the type of housing desired; i.e., one-family home of acceptable style and neighborhood, apartment, mobile home park, or single room.

3. Access to comprehensive consumer facilities such as a supermarket, shops, schools, restaurants, and medical services.

4. Cost and availability of credit (high mortgage interest rates encourage renting; newcomers may have difficulty arranging loans).

5. Access to valued amenities, such as fishing, streams, lakes, scenery, privacy, National Forest lands, golf course, and friends or relatives.

6. The presence of adequate public utilities and services; e.g., water, electricity, sewer, power, and improved roads.

7. Worker income in relation to the cost of housing (professionals are more likely to buy homes; unskilled will more often rent).

8. The state and local tax structure (high city taxes can encourage rural residence).

The adjustment of incoming employees to the community and their eventual acceptance depends in part on the personal qualities of the workers. In predicting this, clues are evident in their age, marital status, whether or not they are

trained-career employees, their level of formal education, work history, etc. On the average, those with the most at stake (rank, income, job security, family) usually make the greater effort to meet community expectations.

In the mining centers of the Region, employment security has been periodically reduced by several factors, including the fluctuating metals market, labor-management conflicts, and changes in mining and processing technology. In some mines employee strikes, for higher wages or improved working conditions, have shut down operations for several weeks or months with significant losses in production and income.

The long-term trends toward open-pit mining and the mechanization of many extraction and hauling operations have substantially reduced work force requirements. As a result, miners are relatively fewer but better compensated than workers in many other industries (Table 4-5). The closing of the several remaining underground mines at Butte and the opening of an

Table 4-5
How Mining Compares with other U.S. Industries in 1989

	Annual rate per 100 employees:			Employees			Employee weekly earnings		
	Group health plans	Accident or Illness (1988)	Deaths per 100,000	Total (1000)	% Unemployed 1979	% Unemployed 1989	1979	1989	Percent Women Employees
Agriculture*	22.0	10.9	40	3199	9.1	9.6	160	249	21.5
Manufacturing	75.0	13.1	6	21652	5.5	5.1	269	430	32.7
Mining	80.2	8.8	43	719	4.9	5.8	365	570	16.3
Construction	50.6	14.6	32	7680	10.2	10.0	342	512	8.9
Transportation, Public Utilities	74.5	8.9	24	8094	3.7	3.9	326	491	28.3
Wholesale	67.2	7.6	4	4611	6.5	6.0	248	395	28.2
Retail	34.1	7.9		19618		6.0	139	189	51.7
Finance, Insurance Real Estate	65.9	2.0	4	7988	3.0	3.1	192	342	59.4
Services	33.0	5.4		38227	5.4	4.8	175	306	61.7
Government	NA	NA	9	17373	3.7	2.8	NA	506	42.9**
Average		8.6		(total) 117,342	5.8	5.3	220	334	45.2

NA: Not available
*Agriculture, forestry, and fisheries
**Public administration only

Source: Statistical Abstract of the U.S., 1984 and 1991

open-pit operation reduced the number of mine employees from 13,000 in 1942 (union estimate) to 1,300 in 1981 (company estimate). During this period, the extraction of ore tonnage increased and the production of copper decreased due to the much lower concentration of metal in the remaining ore. Further reductions followed the decision to close the open-pit mine. In one-industry towns, mine and plant cutbacks imply equally severe reductions in business volume, public services, and secondary employment. Case Studies 4 and 5 in this chapter illustrate these secondary effects.

Quality of Life Concerns

Residents of the large rural expanses of the Northern Region states demonstrate a strong attachment to the land, a fondness for outdoor recreation, and a loyalty to the locality in which they live. Whether the prevailing physical environment is forest, grasslands, or rough and rocky terrain, its uniqueness is recognized and highly regarded by those who call it home. Most newcomers, as well as established residents, are learning to respect the natural environment and are reluctant to alter it without carefully considering the implications of such actions.

Rural westerners differ from city residents. Traditions, such as neighborliness, trust, and mutual aid, are widely shared and upheld as ideals. The wide range of modern facilities and services that have become standard in urban centers are not considered as essential in the small town.[6/] Physical amenities; such as clean air and water, primitive forest, panoramic vistas, privacy, good hunting and fishing, and varied outdoor recreation, are highly valued.

Although local residents often see a need for certain "improvements" in local facilities or some expansion of an often narrow economic base, they are less supportive of large-scale development activities that appear to be inconsistent with existing land-use patterns or disruptive of community life.

A proposed mineral project tends to be most welcome where residents are accustomed to mining and economically dependent on this industry. Exceptions occur when mining communities already experience growth pains from existing projects. Mining activities may also be acceptable to the majority of residents in areas where intensive logging, local quarrying, or other surface-disturbing activities are well established.

In contrast, there is often strong resistance to mineral operations in areas valued for their natural beauty, wilderness qualities, their recreation and tourism potential, their prime agricultural land, or other attributes that could be adversely affected by mineral extraction, processing, or transporting operations.

When the arrival of the plant operating force overlaps with construction activities, the adverse effects associated with excessively rapid population growth tend to increase (see the following section on the boomtown syndrome). When the size of the work force stabilizes, these conditions gradually return to near-normal levels. Community facilities expand to accommodate these newcomers and their families and they become integrated into the community.

[6/] Marans, Robert W. and Don A. Dillman, with Janet Keller. Perceptions of Life Quality in Rural America. Ann Arbor: University of Michigan Institute for Social Research, 1980, 109 pp.

Both formal and informal patterns of social organization are potentially affected by a new mineral project. The company becomes a new political and economic force in the community. Some of its employees eventually occupy positions of leadership and responsibility in local government and voluntary organizations. At the informal level, some newcomers develop friendships with residents, while others feel rejected or ignored and socialize chiefly with other company employees. Some older residents in leadership positions will ultimately be displaced by newcomers with differing conceptions of community needs. Some long-standing friendships may be severed because of job changes, the sale of mineral rights, or changing business fortunes — all relating to the new basic industry in the community.

For Native Americans, the presence of mineral resources on reservation lands is a potential source of controversy and change. Historically, such resources have been left alone or developed by outsiders with little return to the Indian tribe. Tribal leadership today is increasingly aware of the great mineral wealth of western reservations and steps are being taken to ensure wise use of these resources.

The emerging view held by many Indian leaders is that tribes should receive maximum benefits from royalty income and employment. This could, for example, enable tribes to expand their community business sector and benefit from the spending, as well as the earning, of income from mineral holdings. There is also a desire to avoid the adverse effects associated with a large population influx and the disruption of Indian community life.

Federal policy is changing to provide Indian governments with more authority in negotiating mineral development agreements and regulating activities.[7] At the same time, resource-rich tribes are cooperating to exchange information and support one another in negotiating development contracts.

[7] U.S. Department of Commerce. Federal and State Indian Reservations and Indian Trust Areas. Washington, D.C.: U.S. Government Printing Office, 1974.

CASE STUDY 3

Site Development and Production
Stillwater Platinum Mine
Nye, Montana

In 1981 the Forest Service and the State of Montana began an analysis of the potential social and environmental impacts of a proposed platinum and palladium mine, mill, and tailings pond in the Stillwater Valley, about 75 miles west of Billings, Montana. The Stillwater Mining Company had selected a site six miles southwest of the small community of Nye and two miles outside of the Absaroka-Beartooth Wilderness.

Two scoping meetings were held in 1981 to involve interested publics and 130 people attended. Another 500 individuals and groups received questionnaires and 80 responded. A draft EIS was published and distributed for public and agency review in June 1982. Forty-six letters and testimonials were received expressing opinions and concerns about the mine proposal and the alternatives described in the draft EIS. A detailed list of these concerns is included in Chapter 3 to illustrate the section entitled "Potential Environmental Concerns." The final EIS, completed in December 1985, responded to these concerns.

After obtaining written assurances from the mining company that specified measures would be taken to mitigate adverse environmental impacts, the company's plan of operations was approved by the Forest Service in a Record of Decision dated December 23, 1985.

Nature of the Project

The mine was projected to last for about 30 years, including construction (2-3 years), operation (25 years), and reclamation (3 years). It occupies 132 acres of a 550-acre permit area on adjacent National Forest and company lands.

The mine is underground and accessed by several portals. The mining technique used is called "cut-and-fill stoping." Miners excavate stopes (tunnels) at the base of the vein of platinum ore and then blast ore loose from the ceiling a layer at a time.

Loose ore is loaded on ore cars and transported to the mill. The floor of the stopes is gradually elevated with crushed rock that has been returned from the mill after removing most of the metallic compounds. This method avoids leaving large caverns, disposes of the majority of mine waste underground, and gives the miners easy access to the next layer of ore. Altogether, several hundred stopes will be mined and a 20- to 50-foot solid roof will be left intact over the mine cavity to prevent or reduce subsidence.

The mill and tailings pond were constructed on a former mine site to minimize surface disturbance. The mill is needed to crush the ore, to separate out the waste rock, and to concentrate the metallic content of the ore. The finely crushed ore is mixed with water and chemicals, injected with air, and agitated to produce bubbles which attract particles of the desired minerals. These bubbles are skimmed off, filtered, and dried to form a concentrate which is shipped to a smelter. This froth flotation process recovers over 90 percent of the precious metals in the ore.

The tailings pond receives and permanently stores fine particles of mill waste that flow from the mill. Coarse particles are returned to the mine. The pond is contained by a dam and completely lined with an impervious plastic (hypalon) to restrict seepage. The dam is raised periodically to enlarge the pond as it fills, and eventually the pond and dam will cover 70 acres. Water for the mill and pond is collected from mine and surface runoff and from project wells, if needed.

In the operating plan, mine and facilities construction were projected to employ about 300 people for the first 2 years and then to decrease to about 220. Later reports indicate that employment gradually increased to 483 employees by the end of 1990, but to cut costs, the work force was reduced to 364 in March 1991. The administrative staff works a regular 5-day week, miners work in two shifts for 5 days a week, and mill workers work three shifts and a 7-day week. About 40 percent are production workers and local-hire.

The Forest Service and State of Montana have specified many procedures to avoid or reduce adverse social and environmental effects. Requirements include preserving air and water quality, protecting wildlife and fish, preventing subsidence, ensuring adequate reclamation, and reducing social impacts. To ensure compliance, specific monitoring requirements were established to check periodically the effectiveness of

these mitigation measures and to permit corrective action when advisable.

Social and Economic Setting

The mine complex is located in rural Stillwater County. It is 28 miles from Absarokee (pop. 1067) and 40 miles from Columbus (pop. 1573), easily the largest towns in the county. Farming and livestock ranching have been the mainstay of the valley since it was settled, but sporadic mining ventures and increasing tourism also contribute to the economy.

In 1990 Stillwater County's population was 6536, up 17 percent from 1980 before the mine was constructed. The largest growth was in the Absarokee census division, which increased 36 percent, compared to 15 percent in the Columbus division. County growth during the previous decade was 21 percent, but the most rapid increase was in the Park City subdivision at the opposite end of the county near Billings. The county's population is relatively permanent, with over 80 percent of residents buying or owning their homes.

The broad Stillwater Valley is very scenic, with green fields and groves of trees, fast-flowing streams, and an impressive mountain backdrop. Scattered among the numerous livestock ranches are clusters of new homes, mobile homes, and summer cabins, many owned by retirees. Absarokee, in the heart of the valley, is a thriving mountain town. It boasts a bank, several stores, restaurants, a spacious new high school, and a new housing subdivision. Every home appears to be occupied.

A company-sponsored 1981 survey of Stillwater county residents (prior to the mine) revealed that most people were quite satisfied with their quality of life.[8/] They cited the friendliness of the people, the small population, the beauty of the area, and the outdoor recreation opportunities as major reasons. They also registered some dissatisfaction with road conditions, limited community services, and the lack of entertainment options. Yet only 3 percent said they would prefer to live elsewhere.

Some residents expressed concern about limited employment opportunities. The types of economic growth most favored by respondents were recreation (67%), oil and gas development (66%), manufacturing (61%), and underground mining (44%). Of employed persons, 49 percent were in private business, 26 percent in agriculture, and 23 percent worked outside of the county.

Feelings about the effects of mine development were mixed. The most frequently shared opinions were that the result of the project would be:

- Increased jobs: 63%
- Boosted economy: 45%
- Broadened tax base 29%
- Too-rapid growth 30%
- Burden on schools 29%
- Strain on roads 20%
- Burden on other facilities and services (smaller percentages)

[8/] Stillwater County Resident Survey, 1981. Columbus, Montana: Stillwater County Planning Office.

Social and Economic Effects of Development

Currently the mine provides employment for 360 people at an income that exceeds the county average. About 39 percent of the mine and mill workers were hired from within the county, and local residents filled the majority of other new jobs in local government and businesses generated by the mine. In-migrant mine employees and their families contributed approximately 600 people to the population increase.

The new payroll also increased both the level of local business activity and county tax revenues. The combined effect relieved unemployment, which had reached 8.6 percent in 1984 prior to mine construction. It declined to 3.5 percent in 1990 and increased again in 1991 due to mine layoffs.[9/] Statewide, mining employees earned an average of $590 weekly compared to $300 weekly earned by all private, nonagricultural production, sales, and service workers.

Between 1980 and 1990, housing units in Stillwater County increased 23 percent, compared to 10 percent for the state. The Absarokee census division led with a 33 percent increase. The market for housing appears tight, especially for rentals. Home prices are stable but rents are increasing.

Developers of large-scale hard rock mines and related mills in Montana are required by the Hard Rock Mining Impact Act of 1981 to prepare a fiscal impact plan describing how local government units would be affected. The plan must project the population influx, the increase in government operating costs, the assistance the developer will provide if the need arises, how this need is determined, and how the situation will be monitored.

The Stillwater Mine Impact Plan, signed in 1985 and amended in 1988 due to an increase in mine employment, defined Stillwater County, the City of Columbus, Absarokee Fire District, and four local school districts as affected jurisdictions.

As of 1991, the Stillwater Mining Company had taken several steps to offset the costs of development for local government and to assist its employees.

1. Prepaying taxes of $2.3 million to provide community facilities and services for in-migrating mine and mill employees.

2. Offering grants and loans for special projects, reduction of property taxes, or to compensate for a substantial phasedown in operations.

3. Funding of up to 20 percent of road and bridge improvements initiated before 1990 and 10 percent for 1991-1995 improvements on key roads.

4. Purchasing two ranches near the mine to provide temporary mobile home accommodations and loan guarantees to employees who purchase these homes. Employees may also purchase improved lots at reasonable prices and build homes.

[9/] Montana Department of State Lands, et al, Draft Environmental Impact Statement-Stillwater Mine Expansion, May 1992.

5. Payment of principal and interest on educational impact bonds for local schools.

Despite this and other mitigation, some problems remain. The sewer system in Columbus is at capacity and water lines need to be upgraded. Some streets need paving due to increased traffic and some city functions require additional office space. The Columbus elementary schools are at capacity and Absarokee schools are nearly so.

Initially, the in-migrating mine workers and their families were considered outsiders by older residents, but this attitude is changing with time as newcomers get more involved in community activities. Some of the children of incoming workers have had difficulty adjusting to a new school system. The March 1991 layoffs sparked concern among residents that mine employment and revenues are not as dependable as once thought and that the area may need more economic diversification. However, the company is formulating plans for an expansion of the mine and, if approved, this would again increase employment incrementally over several years to a total of about 525 people.

ABANDONMENT OR PHASEDOWN

The closure or phasedown of a large mine, oil field, or processing complex can be a traumatic experience, especially for small mining communities in sparsely populated areas. It is a shock not only to mine and plant employees, but to industry investors and to local and regional businesses that provided goods and services for the facility.

A phasedown or reduction in operations is less critical than abandonment because only a portion of the labor force is laid off. The situation is often temporary, pending mineral price increases that make a larger operation profitable. Case Study 4 describes a phasedown in oil and gas production in western North Dakota.

The loss of several hundred or a thousand well-paid jobs and the resulting out-migration will affect real estate values, the volume of local business activity, school enrollments, organizational membership, and the economic security and outlook of most of the resident population. It may increase the tax burden or reduce the level of services for those who remain in the community. The timely substitution of other basic industries may be the only satisfactory long-term solution to the problem.

CASE STUDY 4

Petroleum Boom and Phasedown
Little Missouri National Grasslands
North Dakota

Earlier in this chapter, Case Study 1 described oil and gas exploration and site development within and adjacent to the Little Missouri National Grasslands of western North Dakota. This rapid escalation of petroleum operations and the resulting economic boom followed in the wake of the 1973 oil crisis. The international OPEC cartel quadrupled crude oil prices, providing a strong incentive for increased domestic production of previously uneconomic oil deposits.

Several major petroleum firms and their numerous contractors initiated or expanded their exploration and site development operations in the Grasslands, and between 1979 and 1985, an average of 160 wells were drilled and a hundred miles of pipeline were laid annually.

Nature of the Boom and Phasedown [10]

The boom was both intense and brief. The high oil prices could not be sustained due to the increase in non-OPEC supplies, a reduction in demand, and the inability of OPEC to keep production levels of member nations within assigned quotas. Crude oil prices fell dramatically from $31.80 per barrel in 1981 to $12.50 in 1986 and have remained at between $12.50 and $16.00 since then.

[10] Wenner, Lambert N. Adapted from Survey of the Social and Economic Effects of Oil and Gas Development: Little Missouri National Grasslands, 1980, 1982, and Social and Economic Assessment of Oil and Gas Activities, 1981. Missoula, Montana: USDA, Forest Service, Northern Region.

The drop in prices discouraged further oil and gas exploration, and by the mid-1980s fewer new wells were drilled. The value of oil production dropped sharply, forcing the shutdown of many marginal wells. Many of the crews involved in exploration, drilling, pipeline installation and support services were either laid off or transferred to other oil-producing areas.

Table 4-6 vividly captures the effects of the petroleum boom in the seven counties that encompass the National Grasslands. Most of the field operations and support services were located in these counties and most petroleum workers resided there. The table shows that prior to the oil boom (1960-1975) most of these relatively rural counties and communities were losing population. Dry years and depressed prices led to farm closures and the consolidation of ranch lands. This encouraged young people to migrate to other areas. But by 1980, petroleum-related in-migration was sufficient to stabilize populations in most jurisdictions. By 1985 almost all counties and communities were growing rapidly, only to have the rates reversed again when oil prices dropped. By 1990 some localities were again at 1970 pre-boom populations.

Table 4-6
Area Most Affected by Oil and Gas Operations on the National Grasslands

County and Community	Year				
	1960	1970	1980	1985	1990
Billings, ND	1,500	1,200	1,100	1,300	1,110
Medora	130	130	90	110	100
Dunn, ND	6,400	4,900	4,600	5,000	4,010
Killdeer	77	620	790	1,000	720
Golden Valley, ND	3,100	2,600	2,400	2,500	2,110
Beach	1,460	1,410	1,380	1,530	1,200
McKenzie, ND	7,300	6,100	7,100	8,700	6,380
Watford City	1,870	1,770	2,120	2,210	1,780
Richland, MT	10,500	9,800	12,200	13,400	10,720
Sidney	4,560	4,540	5,730	6,320	5,220
Stark, ND	18,500	19,600	23,700	26,600	22,830
Belfield	1,060	1,130	1,270	1,540	890
Dickinson	9,980	12,400	15,920	17,510	16,100
Williams, ND	22,100	19,300	22,200	27,600	21,130
Williston	11,870	11,280	11,340	15,590	13,130
County Totals	69,400	63,500	73,300	85,100	68,290

Source: U.S. Department of Commerce, Bureau of the Census, 1991.

Social Effects of the Boom

Some local governments were severely stressed by rapid population growth and economic expansion followed by a phasedown a few years later. The burgeoning population required housing and other county and community facilities and services. The in-migrants were from all parts of the nation and were introducing or extending a complex new industrial technology to a subculture of ranchers, small business men, and seasonal recreationists. The newcomers were relatively young, yet earned more money than most locals. Initially, at least, many of them paid fewer property taxes than established residents and some were less responsive to traditional community standards of behavior.

Most local governments lacked the resources and expertise to deal routinely with rapid growth and change. Public officials and civic leaders met these challenges in various ways. Approaches included inquiring about what other communities had done under similar circumstances, appealing to state and federal agencies for assistance, negotiating with petroleum operators for help, and using trial and error. Sidney, Montana, one of the fast-growth cities, used a very novel and effective approach. A planeload of community leaders with diverse responsibilities visited Douglas, Wyoming, a city of comparable size that had already adapted to rapid oil and gas development. Each person sought out and consulted with Douglas residents who had similar assignments and useful experiences to share.

City and county governments faced somewhat different challenges. Cities were the nerve centers of petroleum operations and most of the newcomers resided there. But the oil and gas operations occurred in the rural areas, under county jurisdiction.

The city's main problem was to provide for the large influx of newcomers, everywhere apparent and sometimes resented by local people. Yet their needs for housing, schools, health care, recreation, utilities, and consumer services had to be met. Property taxes, fees and assessments, bond sales, and federal and state grants were used to finance this expansion.

Many smaller towns experienced uncoordinated growth with mobile home sites and makeshift business premises scattered along highways and among older residences. Business and residential expansion needs outpaced the construction of homes and offices, streets, sewers, sidewalks, water systems, and landscaping.

County concerns included the increased demand for all-weather roads and bridges, changes in land-use patterns, especially outside of each city's limits, and the effects of petroleum development on farm crops, the environment, human health, and livestock. County services that needed to be expanded included family assistance, health and safety, land-use planning, legal aid, law enforcement, extension services, and education. County revenues came from property taxes, fees, state aid earmarked for particular programs, federal payments in lieu of taxes on some lands, and a share of state oil and gas severance taxes.

A persistent problem in fast-growth areas is that expanded facilities and services are needed promptly, whereas much of the increase in public revenues from population growth occurs a year

or two later. Hence, needed funds must be borrowed or obtained through grants. In addition, many of the newcomers lived in rentals or mobile homes and paid relatively low property taxes. Registered mobile homes in Richland County increased from 135 in 1970 to 887 in 1979. Some workers also paid low sales taxes because much of their earnings went to families residing in another state.

Some of the other effects of intensified petroleum operations and related population growth in cities and rural areas were:

1. Prices inflated. Both new and older homes cost more than in normal-growth cities of similar size in the state, and rentals were 25 to 75 percent higher. In some locations, the cost of food and some types of commercial services were also above average. Retired persons, widows, and young families with low or fixed incomes suffered increased financial hardship.

2. Many families perceived net benefits from the boom. Earnings increased for most local businesses, fee-collecting professionals, and landowners with mineral rights or real estate in prime locations. Unemployed workers and spouses could easily obtain jobs, and competition among employees forced wages and salaries upward. College students found summer jobs that paid well and unemployed people from other states arrived to look for work.

3. Many people believed that the quality of community life had declined in important respects. Theft, burglary, assault, and random acts of delinquency were more common. Child and spouse abuse, alcohol and drug abuse, civil suits, and case loads at clinics increased faster than population growth in some communities. Long-term residents often commented on the loss of scenic beauty in the rolling hills and badlands, the heavy traffic and noise, and the need to lock their homes and cars.

4. Officials in most agencies and service institutions reported an increased work load and more problem situations. The majority of schools had budgetary and program impacts. Schools had more students and a higher ratio of transient children with emotional or learning difficulties. Hospitals had more patients and an increase in the demand for emergency services. Law enforcement agencies and the courts had sharply increased work loads and handled a greater variety of civil and criminal actions. Public and private utilities had difficulty keeping up with the demand for extensions of their service.

5. Consumers benefited from new restaurants, retail outlets, and services generated by the increased wealth. More streets and roads were paved and a new shopping center was constructed in Dickinson. Local residents had an opportunity to take new jobs that offered more income or job satisfaction.

6. Ranchers were also divided in their evaluation of the boom. Some gained financially from payments for oil exploration and leases, pipeline installation across their property, contracts to provide services to oil firms, and oil and gas royalties. Others objected to the increases in road traffic, noise, and dust, the illegal dumping of salt water and wastes, the threat of gas poisoning to their livestock, and the harmful effects of dust-laden grass on grazing animals. Sometimes

ranchers had a legal obligation to permit access to mineral rights beneath their land, even though someone else owned those rights.

Social Effects of the Phasedown

It was widely assumed that OPEC would continue to control prices, gradually forcing them upward and that domestic oil production in previously marginal areas would continue to be profitable for many years. With this in mind, counties and communities gradually obtained funding and began their expansion of facilities and services to meet future needs.

The rapid and unexpected decline in oil prices, the phasedown of oil production, the cutback in exploration for new sources, and the resulting out-migration of some oil industry employees reduced both consumer spending and tax revenues. As a result many local governments found themselves saddled with an excess of both facilities and financial liabilities. Local businesses suffered reduced sales and the job market narrowed. New homes and rentals were harder to fill and housing prices decreased. The population of the seven-county area, which had increased 34 percent between 1970 and 1985, now decreased 20 percent during the next 5 years (Table 4-6).

Many residents today favor a resumption of oil and gas operations, but at a manageable rate and with adequate environmental safeguards. Others would like to see greater diversification of this area's economic base, with more emphasis on clean, long-term industries, such as tourism, recreation, and light manufacturing.

In September 1991, the Custer National Forest and the Bureau of Land Management issued a joint Final Environmental Impact Statement for oil and gas leasing in the Little Missouri National Grasslands.[11/] The Forest Service and BLM will determine which lands are available for leasing and can schedule and coordinate leasing and subsequent development, permitting as many as 500 wells over a 10-year period. The EIS anticipates a success rate of 35 percent for wildcat and 90 percent for discovery wells. This rate of development would be much more gradual than the 160 wells drilled annually during the 1979-1985 boom period.

Despite the trend in some areas toward large mines (which employ a growing portion of the shrinking mine labor force), the great majority of mines are still relatively small operations with a limited work force and a much shorter life span than large copper or iron mines. These mining operations include: (1) separating alluvial materials, as in placer mining, (2) extracting and grinding ores, and concentrating mineral content, as in copper mining, or (3) extracting, separating, and sorting nonmetallic minerals that require little processing before use; e.g., sand, gravel, salt, coal, building stone, or clay.

If a small mine closes, the local effects tend to be moderate because the local economy can survive the loss in revenues and perhaps absorb some of the displaced workers in other jobs. Alternatively, another small-scale operation may be started at another site. Newer technology or an improved market situation can make small operations feasible even when a large installation

[11/] U.S. Department of Agriculture, Forest Service, Custer National Forest and U.S. Department of the Interior, Bureau of Land Management. Final Environmental Impact Statement for Oil and Gas Leasing: Little Missouri National Grasslands, September 1991.

would be risky because of the long period required to amortize the investment.

Federal and state laws and agency policies now require site reclamation, usually after construction, during production, and following the abandonment of the facility. In Anaconda, Montana, there is an on-going effort to landscape and revegetate the surface of hundreds of acres of accumulated concentrator wastes.

Coal mine reclamation is now required and monitored under the Surface Mining Control and Reclamation Act of 1977. It is an expensive process, costing an average of $4700 per acre in Montana in 1980, and is now a continuing process in the strip mining cycle (Chapter 2).

Reclamation can be an ongoing process in hard rock mining and petroleum operations as well, involving site landscaping and the revegetation of mud pits, waste dumps, and tailings enclosures. But the abandonment of a large complex operation poses a major reclamation problem. Underground mines or an open-pit may be subject to subsidence, flooding, and possible leakage into fresh water sources. The extensive site facilities (e.g., buildings and other structures) should be removed or converted to other uses to avoid later hazards.

The following case study of the Bunker Hill mine complex in Idaho dramatically illustrates the scope and severity of the effects of the sudden closure of a mine, smelter, and refinery employing over 2000 workers.

CASE STUDY 5

Mine Abandonment
Bunker Hill Mine,
Kellogg, Idaho

Photo from Bunker Hill Mining Company brochure

The Bunker Hill operation was the largest of three important mining complexes that dominated the economy of the "Silver Valley" in northern Idaho's Shoshone County. Bunker Hill was one of the nation's leading producers of silver, zinc, and lead. Company holdings included the century-old Bunker Hill Mine, a large smelter and refinery in Kellogg, and three other area mines.

Bunker Hill produced ores and concentrates for nearly 100 years, employing three generations of miners and metal workers. The main mine at Kellogg is now over a mile deep and consists of 130 miles of adits, drifts, and crosscuts. Annual production was about 225,000 tons of lead and zinc (21 percent of national output) and 9 million ounces of silver (25 percent of U.S. output). By-products included other metals, phosphoric acid, phosphate fertilizer, and tree seedlings nurtured in abandoned mine tunnels.

Social and Economic Setting

The majority of residents in Kellogg (pop. 3417) and Smelterville (pop. 776), plus substantial portions of other neighboring communities, depended directly or indirectly on the company payroll for their livelihood. Bunker Hill was Shoshone County's single largest employer and taxpayer. It directly employed 2040 people in 1981 and stimulated secondary employment

opportunities for an estimated 3500 people in Idaho and eastern Washington. The $55 million payroll accounted for almost a third of the total wages and salaries paid in the county in 1981. Workers averaged $14.52 per hour in income and fringe benefits, up from $7.04 in 1977.[12] State and local tax revenues from company operations exceeded $10 million. In addition, the company made local purchases of commodities and services valued at $15 million and donated both money and services to various community programs.

The smelter and refinery emitted large quantities of allegedly toxic gas which obscured distant viewing on windless days. Tall smokestakes were constructed to disperse the fumes, but were only partially effective. Gas concentrations were most dense on the inhabited valley floor and in exposed soils. It was feared that prolonged exposure was harmful to humans and animals, so the company installed pollution control devices and instituted a program of lawn planting to reduce the danger of harmful effects. Some observers believe the risk is still present in the vicinity of the smelter.

"Black Tuesday"

During 1979 and 1980, the average annual price of silver surged upward, rising from $5.40 to $20.63 per troy ounce. Copper, which is often extracted simultaneously from the same ore, rose from $.66 to $1.02 per pound. Lead and zinc also made substantial gains, and Bunker Hill had a 1980 profit of $31.5 million. The strengthened metals market generated a lot of enthusiasm in the mining communities of the Northern Region.

The prevailing mood in Kellogg and Wallace, Idaho, is captured in this featured news item:

> Silver is king and mining it has become a brand new game. Jobs are plentiful, and if miners can be found to fill them, an already high employment rate will increase.
>
> . . . Everyone is optimistic. Even if there is a recession this year, we don't think we are going to get hurt.[13]

Just 18 months later, on a day dubbed "Black Tuesday," (August 25, 1981), the imminent closure of the Bunker Hill mine, plant, and smelter was announced. The company expected a loss of $8 million in 1981. These news clippings reflect the changed situation.

> People have been saying that Bunker Hill would never shut down. Well, never has arrived. . . . I'll sell you my house; it was worth $70,000 yesterday and it's worth $40,000 today.[14]

The Bunker Hill Company began curtailing its operations in October 1981, and made periodic work force reductions in the months that followed, with senior workers being retained the longest. The closure closely followed the shutdown of the Anaconda copper smelter and refinery in Montana. Both mining companies attributed their decision to a combination of factors beyond their control, including:

- depressed markets and/or declining prices for metals they produced.

- increased labor costs, making it difficult to compete with foreign operations, and

[12] Most information on Bunker Hill was gleaned from a series of articles in The Kellogg Evening News, August 25 to October 12, 1981; The Mining Journal, September 1981; and seven interviews with Silver Valley residents, October 1981.

[13] Missoulian, February 17, 1980.

[14] Kellogg Evening News, August 26, 1981.

- greater capital outlays for the purchase of pollution control equipment necessary to meet new federal and state environmental standards.

Other conditions no doubt contributed to the decision to close one or more of these operations, but may be too speculative to include in this analysis.

On the day following the closure announcement, the Idaho Governor and other state officials visited the Silver Valley to meet with mine representatives. At the same time, a joint state and local task force was formed to find a way to keep the mine complex open or to mitigate the effects of its closure. The Governor said a closure would be a severe economic disaster for the State of Idaho.[15]

The task force immediately began a search for a new buyer. This was urgent because the company planned a rapid shutdown, explaining that it costs almost as much to keep the facility open as to operate it. Once the plant is partially shutdown and supplies of concentrate have been curtailed, reopening becomes both expensive and impractical.

A group of Idaho financiers soon responded with an offer to purchase the Kellogg complex for $65 million if the money could be raised and employees would agree to a reduction in earnings. The local steelworkers' union, representing 1400 of the workers, accepted the purchase plan and agreed to a 25 percent wage cut, but this move was rejected by the national steelworkers' organization, causing the financiers to withdraw from the venture. Subsequent efforts to keep the mine open on a permanent basis also failed, due in part to continuing low prices for silver and the mounting costs of maintaining a very large and deep mine.

Effects of closure

The closure of the Bunker Hill operation has national implications because the U.S. is not self-sufficient in any of the several metals BunkerHill produced. In 1981 this country imported a portion of its antimony (51%), cadmium (63%), gold (7%), lead (10%), silver (50%), and zinc(67%). Increased domestic production would boost the U.S. economy, increase public revenues, and make the nation less susceptible to shortages during periods of international strife.

However, the most severe and immediate effects of the late 1981 closure were experienced at the local and, to a lesser extent, the state levels. Closure of the entire Kellogg complex, which potentially employs 2040 persons, pushed the local unemployment rate to 36 percent, and sharply diminished local consumer spending resulting from a loss of a high proportion of the company's $55-million payroll. It was anticipated that complete closure of the operation would result in loss of 2500 or more Idaho jobs in other occupations due to the reductions in public revenues and business activity, resulting in a total loss of $80 million in wage and salary income.[16] The Spokane area also experienced some loss of business and earned income.

Kellogg Evening News articles following the closure reported that local businesses planned to continue operations, reasoning that the effects of

[15] Kellogg Evening News, August 28, 1981.

[16] Estimated by Idaho State Division of Financial Management, September 1981.

Anaconda's smelter shutdown were not as severe as expected and that the Bunker Hill shutdown may only be temporary. An estimated 90 percent of those unemployed stayed in the valley, hoping to get their old or better jobs back, if and when the operation resumed. With extensions, unemployment benefits were paid out as long as 70 weeks. Those benefits kept the local economy afloat, paying out at times $1 million a month to former workers.[17] By late 1983, however, the seriousness of the closure was becoming apparent. A Kellogg Evening News article dated February 22, 1984, provides the following information:

- Unemployment benefits are exhausted for a large number of the county's unemployed. Only 400 of an estimated 1800 unemployed currently qualify for unemployment benefits.

- Requests for county welfare have gone up sixfold in the past year, and most of the county's indigent fund [18] is expected to be exhausted less than halfway through the year.

- Shoshone County food stamp recipients have increased 23 percent between August 1983 and January 1984.

- The Shoshone County food bank fed 200 families in January 1984 compared to 140 in December and 85 in October 1983.

- Over 2000 households (a third of all households in the county) are listed as low-income and the number is growing.

- Approximately 1000 families have applied for federal energy assistance this year and an estimated 1000 more are eligible.

County and city tax revenues declined sharply. Bunker Hill paid $1,588,000 in property taxes to local governments, and Kellogg's share, $253,000, was close to 30 percent of the city's revenue. Some out-migration of residents will further reduce this tax base and others will be unable to pay them. It is estimated that home property values decreased by one-third in the 2 years following the Bunker Hill closure.[19]

A 50 percent reduction in elementary school enrollment was attributed to the younger families relocating. High school enrollment fell approximately 10 percent since the closure. Families with older children are not moving and most have no plans to do so. A larger percentage of students that remain may have emotional problems relating to increased stress at home.

High unemployment rates have led to a rise in crime in the county. Felonies increased from 57 to 93, and misdemeanors increased from 32 to 98 between 1982 and 1983. Juvenile crimes approximately doubled during the same period.[20]

Other effects are more difficult to quantify. Family life, church membership, political life, and voluntary group participation are apt to be affected. Friends and relatives may be separated by out-migration or local job changes. For some individuals the increased stress will become

---

[17] Kellogg Evening News, February 1984.

[18] Idaho State Law says, "The boards of county commissioners shall . . . care for and maintain the medically or otherwise indigent." An indigent is defined as any person who is destitute of property and unable to provide for the necessities of life.

[19] Kellogg Evening News, March 9, 1984.

[20] The Spokesman Review, March 11, 1984.

evident in rising levels of drug abuse, divorce and separation, child abuse, or suicide. The extent of these behaviors may be quite limited if persons affected by the closure receive financial help and strong emotional support from friends, relatives, the union, and public agencies. In long-established mining communities (unlike boomtowns), these supports can be very substantial.

In the 1970s, smelter smokestacks discharged hundreds of tons of lead, threatening the health of local residents. Intensive environmental cleanup and reclamation operations began in 1983, following EPA declaration of a 21-square mile Superfund site around the mine. These efforts continue today.[21]

On the positive side, there are a number of other activities and programs planned in Shoshone County that may, in part, compensate for the economic and social hardships caused by the Bunker Hill closure. These operations may, in time, offset some of the losses and inequities resulting from shutdown of the Bunker Hill and other local operations.

Because humans have the capacity to adjust to a wide variety of situations, the local situation should eventually stabilize through some combination of population outflow, the creation of new industries, and individual redefinition of living standards. Most displaced families will, in time, become integrated into new social settings. In a sense, the social costs of the closure will have been paid, but not in an equitable way.

[21] "Bunker Hill Cleanup Inches Forward." Idaho Statesman, March 7, 1992, p. 6c.

MINING COMMUNITY LIFESTYLES

Mining differs from other occupations in several important respects. It is male-dominated, although the fraction of female employees is slowly increasing. Many mine operations are hazardous,[22/] tedious, and dirty, but the pay is relatively good. Good health, physical strength, and an aptitude for working with machinery are important job qualifications.

Major mine and plant facilities usually are owned and operated by large corporations with national or multinational interests. Thus the economic well-being of the local community is subject to decisions made by "outsiders" whose first loyalty ordinarily is to the corporation and its stockholders.

Mining is frequently the major economic activity in Rocky Mountain communities where large mineral deposits are being extracted and processed. These communities are often quite distant from other cities. When 50 to 100 years are required to deplete the deposit, mining becomes an intergenerational occupation. Sons follow the example of their fathers and remain in the same town, occasionally in the same residence. In many cases, a miner, most of his friends, many of his neighbors, and some of his relatives are employed by a single company. All of these factors encourage the development and perpetuation of distinctive community lifestyles.

Mining community lifestyles are found in three quite different settings. Three examples are the one-industry (but increasingly conventional) community, the "boomtown," and the occasional "company town," constructed for mine or plant employees and sometimes owned and managed by the mining company. The mining subculture described below exists in all three settings but is most clearly defined in the stable, one-industry mining town and the established company town.

The Mining Subculture

The established American mining community may have begun as a boomtown one to four generations ago, but in most cases its population has stabilized or is now declining. Local residents have a wide circle of relatives, friends, and acquaintances, and identify with their town and area. Distinctive community values and norms have emerged. Recent interviews and conversations with professional people, who have lived and worked in a variety of settings, suggest that social relationships and institutional patterns in established Montana and Idaho mining and smelting towns often differ from agricultural or commercial centers of similar size.

The physical appearance of many traditional western mining communities is the most obvious distinction. There are many small, older homes, often narrowly spaced because of the scarcity of level ground. The growing season is short (mines are often at high elevations), and there may be relatively few well-groomed lawns, gardens, and parks. Some residents who are fond of their community and demonstrate strong loyalty in other contexts may not actively support "grass roots" efforts to beautify or modernize the community, according to some observers. In and

[22/] This has been the prevailing pattern, but the present trend, motivated in part by federal and state legislation, is toward less hazardous surface operations and improved lighting, ventilation, and safety precautions in underground facilities.

around the mining town, one finds evidence of past and present mining activities: the active and abandoned sites, canals or aqueducts, deteriorating buildings, equipment, waste dumps, and tailings ponds.

Family interaction often centers outside of the home, with relatives, at the church, and in restaurants, bars, and clubs. Family ties are nevertheless strong, and extended family activities; such as weddings, parties, or funerals are important and well-attended. Outside activities, such as hunting, fishing, and snowmobiling, are also popular and a lot of money is spent on four-wheel drive vehicles, rifles, snowmobiles, and other equipment.

Mining is dangerous and often strenuous work and forges a close comradeship among miners that carries over into social activities outside of the mine. Strength and proficiency in manual skills are prized, and drinking and storytelling are favorite ways to pass time. Some local mine and plant managers are civic-minded and participate in community activities. Social barriers between managers and employees are low in some towns, and these groups may interact frequently in nonwork settings such as stores, restaurants, or the local Elk's Club.

Historically, strikes have been a fact of life in mining towns and affected most of the population. Strikes sometimes lasted several months and greatly reduced the otherwise substantial incomes of mine workers. Often the community is supportive of strikers. When the strike fund is depleted, county services and credit from merchants are needed to bridge the gap in income. Most miners have rather limited savings. However, if other residents sense that a strike is ill-timed or that the miners' demands are unreasonable (their income usually exceeds most other job holders), community support may be withdrawn. In any case, the county is obligated to provide basic medical, food stamp, dental, heating, and other support services to strikers.

Many businessmen, like miners, are intergenerational. They inherited their businesses, owe no debts, and can weather strikes and recessions better than new enterprises can. Established businessmen are often community leaders and tend to be reasonably satisfied with the existing order, sometimes to the dismay of newcomers who see a need for change and "improvements."

In communities visited, school officials indicated that most of their pupils come from reasonably stable homes and neighborhoods and present no special problems for their teachers. They show an average range of scores on nationally standardized achievement tests. There are, however, migratory families whose children do not have the advantage of such stability and often have academic or emotional problems.

There is some evidence that mining communities are losing their distinctive qualities and entering the mainstream of American life. Modern transportation, communication (especially television), extended public schooling, and increased family mobility combine to reduce the social and cultural isolation of rural mining towns. Some current trends noted by social services personnel in mining towns were:

- increased emphasis on obtaining modern homes and buying rather than renting them;

- a more balanced sex ratio in the town and a de-emphasis of all-male social activities; and

- a decline in the number of "rootless" people who stay a few weeks or months and move on.

The Boomtown Syndrome

Sometimes rapid mineral development stimulates a population influx that persistently exceeds local efforts to supply the required facilities and services and a "boomtown" is created. Only a fraction of communities experiencing development become boomtowns, which usually result from a combination of factors; i.e., (1) a sparsely populated area, (2) large-scale, extended development involving a sizable incoming work force, and (3) insufficient advance planning to accommodate the population influx. Case Study 4 in this chapter describes oil and gas boomtowns.

Business travelers and tourists can easily recognize a boomtown. It is necessary to book lodgings weeks in advance, and the room thus obtained is often noisy, poorly maintained, and expensive. Restaurants and bars are thriving, and a number of new businesses in makeshift premises can be seen. There is an unusually large number of mobile homes, some in newly-established, crowded, unpaved parks and others scattered randomly on vacant lots or in the yards of older homes. Many homes lack lawns and shrubbery. Traffic jams occur during rush hours due to the limited number of arterial streets and railroad crossings. Dust and litter tend to exceed normal levels.

Recent research depicts social life in energy boomtowns, but published data on conventional mining communities is limited. It is important to emphasize the distinction between the two. Boomtowns are characterized by unusually rapid population growth, hasty expansion of housing and support services, and relatively weak social and cultural ties. In the true boomtown, the majority of people are recent in-migrants from diverse locations. Their common goal is economic gain, whether this means a job that pays well, a chance to start a business, or a way to get rich quickly—sometimes by devious means.

In the boomtown the population turnover is great because of housing shortages, insufficient community support services, and the absence of strong emotional ties, community pride, and traditions of mutual aid among friends, relatives, and neighbors. Also, the influx of workers may in time exceed the available jobs, thereby increasing the county social services case load.

Boomtown conditions can be stressful for both newcomers and established residents (Table 4-7). For newcomers, inadequate housing, limited personal services, the absence of close friends and relatives, the shabbiness of a rapid-growth town, and the often limited recreational opportunities are conducive to discouragement, depression, and increased alcohol and drug use. The lack of both career opportunities for women and day care centers for children means that some women who would otherwise take jobs or do

Table 4-7
Some Observed Consequences of Rapid, Extended Change for Social Institutions in Boomtown Settings

Individuals and Family Groups	Quality of Neighborhood and Community Life	Schools, Churches, Voluntary Associations	Community, County Government	Social Aspects of the Economic Sector
Shortage of adequate housing; inflation of prices and rentals	With continuing in-migration, greater racial, cultural, and lifestyle diverstiy	New churches established; greater variety of denominations and sects	Political activity more intense, competitive; wider participation	Decline in production due to absenteeism; employee turnover due to worker out-migration
Local inflation surpasses national average, creates hardship for persons with fixed incomes	Increased support for newer, less conventional social and cultural activities in the community	New challenges to conventional morality and established customs of existing groups	Public services overburdened: police, fire, libraries, hospital, jails, juvenile homes, social services, parks, swimming pools	TV cable, telephone, power companies unable to meet hookup demands
Greater incidence of anxiety, mental illness, alcoholism and other drug abuse, and suicide	Improved social and employment opportunities for women and minorities	Organized groups oriented toward conservation and environment or resource development become more prominent	Increased traffic, street damage; inadequate parking; abandoned cars	National chains open branch operations; some small businesses are displaced
Increase in the frequency of divorce, separation, remarriage, and illegitimate births	Decline in the effectiveness of informal community controls and an increase in formal/legal relationships	Crowded schools; demand for more classrooms, buildings, personnel (25-30 percent of all newcomers are school children); more competitive athletic teams and other groups; also more difficult to join	Public utilities insufficient: water, sewer, and power generation facilities	Shortage of responsible professionals and technicians: doctors, lawyers, dentists, TV repairmen, carpenters, mechanics, electricians, plumbers
Improved job opportunities, especially in rural areas	Multiple-family occupancy of some single-family dwellings; other makeshift living arrangements	Social clubs and lodges gain membership; new leadership patterns may emerge	Uncoordinated real estate development	Loss of trained employees to higher-paying jobs
Greater percentage of mothers employed outside of home	Increases in most categories of adult crime and juvenile delinquency; more people lock their homes and cars	Some shifts in relative prestige and influence of different organizations	Revenues for expanding facilities either very inadequate or 2- to 3-year lag behind needs	Rising unemployment: boom gets national publicity and excessive in-migration of jobless
More frequent abuse of spouses and children	Greater competition for and utilization of recreational facilities	Conservation groups increase their activity and prodevelopment factions often respond with public relations programs	Time and money required to plan and channel future development	Retail outlets unable to handle business volume with former courtesy and efficiency; loss of valued employees to energy jobs. Real estate, construction, mobile home, vehicle dealerships, other growth-related businesses thrive
Some young people drop out of school to take well-paid jobs	Realignment of friendships as new issues generate cleavages and new contacts permit alternatives	New voluntary organizations form to deal with selected effects of development	Possible increases in litter, animal control problems	Income redistribution due to higher rents, wages, profits, and land values; some people gain, and others lose
Increase in the percentage of single male adults, at least during initial phase of activity	Increased noise, pollution of air and water; more litter on streets, sidewalks, and highways		Long-range prospect of gains in per capita revenues	

volunteer work are housebound. The large percentage of young male residents results in a lopsided emphasis on male-centered interests and activities, with women often feeling left out or slighted.

Usually a boomtown is a temporary situation. Conditions tend to normalize within a few years when the population eventually stabilizes, the business sector expands enough to meet consumer demands, and public service institutions make needed adaptations.

The Company Town

The company town was once a common solution to the problem of housing industrial workers in the remote areas of the West. Hard rock mining, petroleum, lumber, railroad, and coal companies have constructed such towns, often complete with schools, churches, and company operated stores.[23/] In other instances, homes or boarding houses were provided by mining, oil, timber, and agricultural firms and public agencies when their employees had access to existing community facilities. Potlatch (lumber) and Stibnite (metals) in Idaho, and Bonner (lumber) and Colstrip (coal) in Montana provide local examples of company towns.

Most of the 200 known company towns in the U.S. were established around the turn of the century when the West was sparsely populated. Many have since shifted to resident ownership and some have been abandoned. Sometimes the mineral or other resource has been depleted; in other cases, the motive for company sponsorship no longer exists. With improved systems of transportation, today's employees often have other options with a greater range of facilities. Yet a few company-administered towns remain in the U.S., chiefly in remote locations, and more exist in rural Canada and abroad.

The feasibility of company towns was recently being re-examined in the anticipation of major new minerals projects, especially coal-fired power and synthetic fuels plants that would bring thousands of additional employees into very rural areas. Colstrip Mine was expanded by Western Energy Corporation, and Exxon began construction of a company town called Battlement Mesa to house workers at its now abandoned colony oil shale project in southern Colorado. The plan called for 7000 dwelling units plus sites for the usual community facilities. Provision was made for self-government and for individual ownership of some homes and businesses.

Company towns greatly reduce the population impacts of major new projects and provide an incentive for workers to move to remote areas. Necessary facilities can be constructed in advance of the need for them. A well-designed and managed community can provide quality homes, reasonably-priced goods and services, and opportunities for democratic participation in community government. This contributes to work force stability and can improve the morale of the residents.

CHAPTER 5:
Mitigating Adverse Effects

As broadly defined by Congress and executive direction, the Forest Service is responsible for managing all National Forest System lands. As explained in Chapter 3, this includes the obligation to consider the social, economic, and environmental effects of its activities and to involve the public in its planning and decisionmaking processes. National Forest users and state agencies share some of the responsibility to protect the environment and affected people.

Sparsely populated counties and towns frequently lack both the financial resources and professional expertise to anticipate and to manage the complex pattern of social and economic effects generated by a major new facility or a combination of smaller projects. Local governments and individuals may register their concerns with appropriate agency personnel but do not have a direct vote in many resource allocation decisions. Hence, it is important that the mineral industry and responsible resource agencies accurately project and monitor the social and environmental effects of such programs so that:

1. Agency budgets and staffing permit effective minerals program administration.

2. The project is designed to avoid adverse impacts whenever possible and to recognize them when they do occur.

3. Corrective measures are taken when needed.

Environmental impact analysis provides the means to identify adverse social and economic impacts and to find ways to avoid or mitigate these conditions. No two projects are identical and preliminary scoping (Chapter 3), issue identification, alternative formulation and evaluation, program implementation, and subsequent monitoring must be appropriate to each situation. This chapter presents some guidelines for identifying problems and suggesting solutions.

The Council on Environmental Quality (CEQ) regulations require that environmental impact statements include mitigation measures to avoid or minimize potentially adverse environmental effects. Agencies must also include provisions for monitoring and enforcing such mitigation. The National Forest Management Act of 1976 (NFMA) extends this requirement to other actions as well. NFMA states that Forest Service planning at all levels should be coordinated with equivalent and related planning efforts of other federal agencies, state and local governments, Indian tribes (36 CFR 219.8), and intermingled landowners. "Monitoring and evaluation will be conducted that includes consideration of the effects of National Forest management on land, resources, and communities adjacent to or near the National Forest being planned . . . ." All public issues and management concerns are to be investigated and evaluated in order of their apparent importance (219.5). In the Regional and Forest planning process, the interdisciplinary team must estimate and display the physical,

biological, economic, and social effects of implementing each alternative.

ISSUES TO RESOLVE

Increases in the level of mineral activities tend to heighten public interest in the issues, concerns, and opportunities associated with mineral development and production. In Forest Service usage, "issues" are questions, conflicts, or dilemmas identified by Forest publics. "Concerns" are analogous to issues but originate within the agency. Often public issues are also agency concerns, so a rigid distinction between the terms is inappropriate. The agency must determine which issues are most important and make a serious effort to address them in each environmental analysis.

Most issues and concerns relate to the social, economic, and environmental situations described in Chapter 3 and are often interdisciplinary in scope. Some issues are commonplace, emerging with most major project proposals. Others may be unique to particular situations. Some of the "generic" issues often identified in environmental analyses relating to mineral activities are summarized below. Each is followed with a brief discussion drawn from public comments and press items.

Generic Issues

National need for minerals. Some people are disturbed by the level of U.S. imports of raw materials and would like to see increased domestic production. Comparisons have been made with the former Soviet Union, which was said to be almost self-sufficient in minerals. Some observers believe that the U.S. does not yet have an effective national policy to encourage nonfuel minerals development and that many competitors have the advantages of cheaper labor and fewer environmental restrictions. Increased domestic production would reduce the outflow of investment capital and jobs.

Another view is that U.S. industries freely participate in an expanding and increasingly unrestricted international market. U.S. firms compete with other countries in product sales and are able to purchase raw materials at the lowest possible cost. American consumers thus benefit from lower prices for factory goods and reserve some domestic minerals for future use. The U.S. is still one of the world's most self-sufficient countries in mineral production, and it imports mainly raw materials that are not available or would be more expensive to produce in the U.S.

A third perspective derived from state and national surveys suggests that a majority of Americans perceive a need to balance the nation's demand for raw materials with other land-use requirements and a growing concern for the environment. Minerals development is essential but some individual proposals may be too costly socially or environmentally. Options, such as recycling and the substitution of other materials, should receive more emphasis.

Economic growth and expanded employment. The 1980-1982 slump in the construction and forest products industries has underscored the need for local industries that provide year-round employment. Rural areas are no longer as economically self-sufficient as they once were. Many small, diversified farms and the local truck garden, flour mill, laundry, creamery, sawmill,

foundry, power plant, and comparable productive activities have been displaced. Over 80 percent of the country's commercial goods and services are now produced by regional and national corporations which also employ the majority of workers.

Most families and communities are now very dependent on large-scale business and industry for jobs, housing, food, clothing, factory goods, entertainment, consumer credit, and medical and personal services. For many Americans, a stable, steadily-growing economy is our first priority.

Unequal distribution of monetary costs and benefits. Some observers perceive gross inequalities in the distribution of benefits and costs of mineral development. Absentee stockholders, corporate managers, contracting firms, and some local landowners and businessmen are made wealthier. Additional local employment usually is created, and local revenues may eventually increase. But these gains are offset by "externalities," costs that people outside of the industry must pay. Additional public utilities, streets, police and fire services, school classrooms, and hospital beds are required. Local inflation increases prices and rents for all. People with fixed incomes often suffer hardships. Local residents experience noise, dust, chemical pollution, inadequate community services, and other unwanted lifestyle impacts.

Reducing demand through effective conservation. A large segment of the public believes that Americans consume far more minerals and fossil fuels than necessary through frivolous uses and waste. We then perceive this high demand as a basic need and seek to sustain it. This is a complex, well-documented perspective and one that has considerable public and scientific support.

Most other highly industrial countries consume energy and raw materials at about 40 to 60 percent of the U.S. per capita rate. Yet in their standards of health, nutrition, average literacy, life expectancy, cultural opportunities, and in their absence of crime, urban blight, and poverty, these nations equal or exceed the United States. Conservation, including durable product design, increased use of renewable raw materials, and recycling, appears to offer the largest quantity of "additional" supplies at lowest cost and without adverse environmental consequences. It enables us to reduce imports and assures future generations of a more adequate resource base.

Criticisms of this view are that continuing economic expansion contributes to full employment and a rising living standard, that recycling is sometimes unprofitable, and that minerals are plentiful if access to new sources is permitted and market conditions encourage additional development.

Resource agency capability. Mineral activities are expanding on public lands in the West. Some Northern Region residents wonder if the Forest Service and other responsible public agencies have the quality of resource inventory, adequate staffing, and sufficient funds to administer leases and other mineral activities. This includes establishing and enforcing reasonable standards for site development and monitoring the effects of ongoing activities.

Minerals development as a priority activity. A segment of the public regards mineral development as essential, desirable, and inevitable.

Supporters of this viewpoint believe that other resources and uses should give way when conflicts exist because "minerals are where you find them." The mineral resource is usually higher in measurable economic value than other resources in their proximity. Environmental and community impact legislation is perceived as excessive, costly, and antiproductive.

The sanctity of existing natural areas. Wilderness and wildlife supporters believe that the best remaining primitive and wilderness areas of the West should be preserved. They point out that much of the grandeur of this region has already been diminished by development. The remaining wildernesses, old-growth forests, wetlands, and other relatively undisturbed areas should be protected from further threats to wildlife, vegetation, scenic values, and water quality. Mining is perceived as incompatible with these values. Large, protected areas are important for plant and animal species preservation, scientific study of ecosystems, back country recreation, and other purposes.

A frequently-voiced public concern is that road construction in previously unroaded areas will result in greatly increased use. The result is a gradual deterioration of wildlife habitat, water quality, and traditional opportunities for dispersed recreation.

The desire to avoid "boom and bust" cycles. Many citizens favor economic growth at a manageable level but disdain a "boom and bust" sequence. Some wonder why public lands are not opened for mineral activities on a staged basis rather than all at once. This would encourage gradual development over years of time and substantially reduce social, economic, and environmental impacts.

One of the most serious public concerns is whether or not a proposed project will actually occur and, if so, when. Operators or resource agencies may withhold information that would help affected communities plan ahead. Local governments are reluctant to commit funds for public facilities expansion if additional revenues may not be forthcoming.

Effects on women and minorities. Recent studies and articles have discussed the effects of development activities, including mineral fuels, on female residents. Different perspectives are emerging. Some writers perceive difficulties for women in rapid-growth, male-dominant energy boomtowns, but there may also be expanded economic opportunities for women in technical and professional occupations, as well as the more traditional fields of business management, public agencies, teaching, nursing, sales, and office work.

Rapid change may reduce the stability of ethnic communities and hinder their efforts to preserve their heritage. Past resource development on Indian reservations has seldom produced lasting benefits in the form of increased employment or improved social conditions. Development near reservations tends to increase the intensity of outside influences and pressure for changes in tribal life.

Environmental quality. Usually this is the most extensive area of concern. State and federal laws, Forest Service policy, and the public interest require careful attention to the environmental

effects of minerals and other resource programs. These are discussed in detail in Chapter 3.

MITIGATION OPPORTUNITIES

Agency Activities

Leases, permits, and operating plans include provisions to protect physical and biological resources, such as water quality, soils on steep terrain, or endangered species.

Comparable procedures have not been developed for controlling social and economic effects in communities affected by Forest Service programs even though NEPA requires that such effects be identified and considered (40 CFR 1502.14, 1502.16, 1508.8, and 1508.20). Forest managers have other opportunities to avoid or reduce adverse effects on these people and to increase their benefits. Social and economic impact mitigation for major activities should include:

1. Keeping the public informed of impending developments and providing interested persons with an opportunity to express their concerns and suggestions regarding Forest programs. This is the public participation requirement of NEPA and NFMA.

2. Assessing the social and economic characteristics of the area potentially affected by Forest minerals programs. Projecting the potential effects of proposed activities, including cumulative effects resulting from other ongoing or impending operations within commuting distance. If development occurs, the resulting data could guide Forest decisionmaking, county land-use planning, commercial and residential development, and the expansion of schools, hospitals, and utilities. Periodic reassessments following significant changes would keep the scenario current and take into account any unforeseen trends.

3. Cooperating with other resource agencies, the mineral industry, state and local governments, and the owners of mineral rights in identifying and helping to mitigate the adverse effects of mineral programs. A joint steering committee supported by these component organizations can provide leadership and direction for this effort. The States of Utah and Colorado have programs to facilitate such cooperation (Bibliography).

4. Planning and coordination of petroleum and other development programs to avoid severe impact situations. This might involve:

a. Scheduling development activities to avoid the simultaneous occurrence of labor-intensive phases.

b. Allocating sufficient budget and manpower to administer the local minerals program. Assigning personnel with a knowledge of the social, legal, technological, and environmental aspects of this activity.

c. Coordinating specific activities to avoid serious use conflicts.

d. Consulting with other resource agencies and local governments involved to ensure an orderly, uniform administrative process.

e. Encouraging local hiring when appropriate skills are available in communities within commuting distance. This sharply reduces impacts on housing, public services, and area lifestyles.

Industry Options

A responsible operator can reduce adverse effects of mineral activities and earn the support and appreciation of the public and cooperating public agencies. Achieving this goal takes time and entails a commitment of operators and their contractors. Local managers must be aware of local community and agency concerns, have enough flexibility to adapt programs to the needs of individual communities or areas, and conduct responsible field operations. The company's commitment should include voluntary compliance with legal and moral requirements to protect other resources and personal property, open communication with people who are affected by company programs, technical or economic assistance to heavily impacted communities, neat-appearing equipment and facilities, an emphasis on local hiring of qualified workers, and a willingness to train apt local people for semi-skilled positions.

Some firms (Chapter 4 case studies) strive to meet these obligations in the belief that it is both good public relations and reasonably cost-efficient in the long run. For example, local workers are already housed, there are classrooms for their children, and local-hire workers are often more productive than nonlocals. When a company is open, honest, and willing to work with others, it reduces duplication of effort, fewer lawsuits result, agencies cooperate more enthusiastically, and communities tend to be supportive of the company and its local employees.

Community Approaches

Communities vary in their mode of organization, in their degree of integration, and in the quality of their social relationships. Each social milieu tempers the effects of growth and change, and any specific development project affects each community somewhat differently. Some factors which enable communities to cope with development and to reduce its adverse effects are:

1. An established procedure for managing development; e.g., zoning policies, systematic planning, and provisions for coordinated expansion of housing, streets, utilities, and services.

2. Local government efforts to monitor the situation, to enforce existing policies and ordinances, and to respond promptly to emerging needs. This implies a prior assessment of community needs, feasible options, and available state, federal, and private assistance. Generally, smaller towns and counties that lack a staff of experienced specialists will have the most difficulty dealing with economic growth and associated social change.

3. Pride in community which motivates residents to strive to maintain quality of life standards in the face of rapid growth. This would include "grassroots" efforts to keep neighborhoods livable, to curb delinquency, etc.

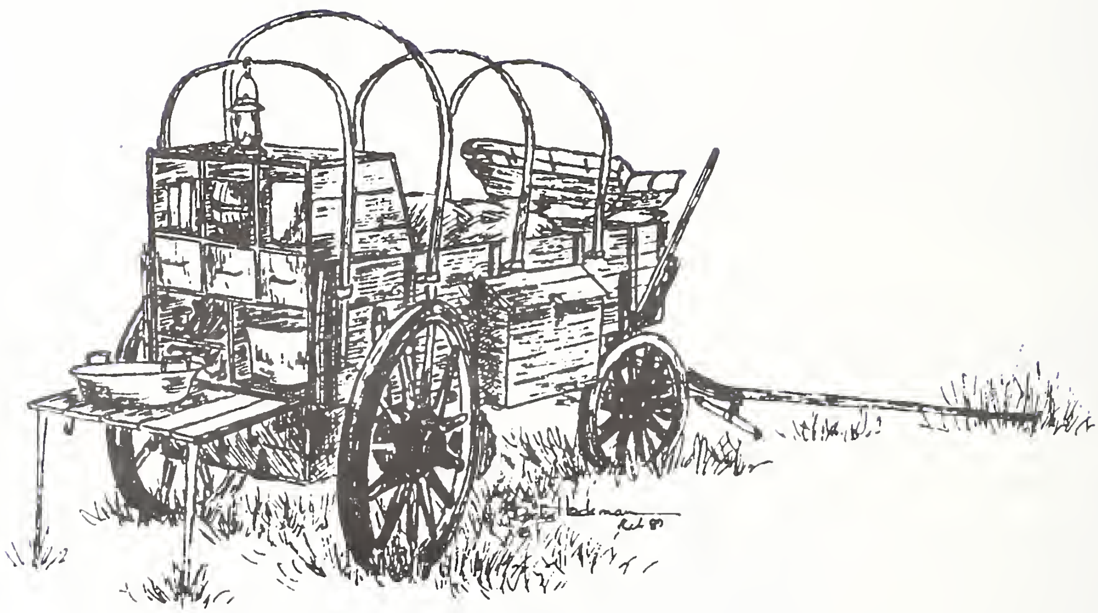
Frequently voluntary organizations (clubs, lodges, churches, or civic groups) aid and complement local government by providing leadership and resources for identifying and mitigating problems.

4. A community social system that is open enough to accept responsible newcomers. The alternative is to alienate them, encouraging a retreat to their occupational subculture. The community thus loses some opportunities to influence newcomer behavior and to profit from their active participation in community life. This accentuates the newcomer-oldtimer cleavage and may lead to increases in the frequency of illegal or discourteous behavior directed toward the opposite faction.

Sources in the bibliography suggest many additional approaches to both project monitoring and effects mitigation in energy development.

MONITORING PROCEDURES

Specific monitoring procedures should be included in environmental documents, project operating plans, and lease stipulations. These may require the operator to make periodic inspections and reports on designated conditions; such as air and water quality, impacts on wildlife or recreation, and soil erosion. Agency personnel need to review such documents and then make periodic site visits to confirm findings and to observe whether any social or environmental developments require additional attention.



BIBLIOGRAPHY

Most references are available in major university libraries and in the Social Analysis Library collected by the author (Office of Environmental Coordination, U. S. Department of Agriculture, Forest Service, P.O. Box 96090, Washington D.C., 20090-6090.

Handbooks and Guidelines

U.S. Department of Agriculture, Forest Service. Social Impact Analysis Handbook (FSH 1909.17, Chapter 30), 1983. Provides guidelines for implementing FSM 1973.

U.S. Department of Agriculture, Forest Service. Environmental Policy and Procedures Handbook (FSH 1909.15).

U.S. Department of Agriculture, Forest Service. Public Participation Handbook. A public involvement handbook in 3 volumes, 5 parts.

U.S. Department of the Interior, Bureau of Land Management. Guide to Social Assessment (coal emphasis), prepared by Mountain West Research, Inc., Billings, Montana, 1982, 330 pp.

Leistritz, F. Larry and Steven H. Murdock. The Socioeconomic Impact of Resource Development: Methods for Assessment. Boulder, CO: Westview Press, 1981, 286 pp.

U.S. Department of Agriculture, Forest Service. The Principle Laws Relating to Forest Service Activities. Washington, D.C.: U.S. Government Printing Office, periodically updated.

Executive Office of the President. Council on Environmental Quality. Regulations for Implementing the National Environmental Policy Act (40 CFR 1500-1508, July 1986).

U.S. Department of Agriculture, Forest Service, Northern Region. Our Approach to Oil and Gas: Analysis, Documentation, Leasing. Missoula, MT: USDA Forest Service.

U.S. Department of Agriculture, Forest Service, Northern Region. Social and Economic Assessment of Oil and Gas Activities: Information and Guidelines, by Lambert N. Wenner, Missoula, Montana: Minerals and Geology Staff Unit, 1981, 110 pp.

Research Findings

U.S. Department of Agriculture, Forest Service, SEAM. Socioeconomic Impacts of Coal Mining on Communities in Northwestern New Mexico, by Lynn A. Austin, et al. New Mexico State University AES Bulletin 652, 1977, 118 pp.

U.S. Department of the Interior, Bureau of Land Management. Literature Review: BLM Social Effects (of Coal) Project. Billings, MT: Mountain West Research, Inc., December 1980, 529 pp. See also: Summary Research Report, 1982, 308 pp.

Council on Environmental Quality in cooperation with USDA, DOE, and EPA. Public Opinion on Environmental Issues, 1980, 49 pp.

Davenport, Joseph III, and Judith Ann Davenport, Eds. The Boom Town: Problems and Promises in the Energy Vortex. Laramie: University of Wyoming Department of Social Work, 1980, 212 pp.

Finsterbusch, Kurt. Understanding Social Impacts: Assessing the Effects of Public Projects. Beverly Hills: Sage Publications, 1980, 309 pp.

Murdock, Steve H. and F. Larry Leistritz. Energy Development in the Western States: Impact on Rural Areas. New York: Praeger, 1979, 363 pp.

Marans, Robert W. and Don A. Dillman, with Janet Keller. Perceptions of Life Quality in Rural America. Ann Arbor: University of Michigan Institute for Social Research, 1980, 109 pp.

National Academy of Sciences, the National Research Council. "Surface Mining of Noncoal Minerals," 1977.

Summers, Gene F., et al. Industrial Invasion of Nonmetropolitan America: A Quarter Century of Experience. New York: Praeger, 1967, 231 pp.

U.S. Department of Agriculture. Using our Natural Resources: 1983 Yearbook of Agriculture. Washington, D.C: U.S. Government Printing Office, 1983.

Statistical Abstract of the United States. Washington, D.C: U.S. Government Printing Office, annual publication.

Information Please Environmental Almanac. Boston: Houghton Mifflin Co., 1992.

Engineering and Mining Journal, published monthly.

Mining Record, published monthly.

Environment, published monthly (most months).

Oil and Gas Journal, published monthly.

Selby, John and L.N. Wenner. Social Analysis: An Annotated Bibliography for Forest Service Programs. Washington, D.C: USDA Forest Service, Office of Environmental Coordination, 1984.

Blahna, Dale and L.N. Wenner. Social Analysis: Supplementary Edition (to above), 1986.

U.S. Department of the Interior, Bureau of Mines. Minerals Today, special environment issue, May 1990.

Chamberlain, Peter and David Forshey. "Technical Advances Needed by the Mining Industry," in Minerals Today, April-May 1988, pp 7-20.

Ary, T.S. "The Mining Industry Bounces Back," in Minerals Today, January 1990, p. 18.

Wetzel, Nicholas and Russell Raney. "Stillwater Mine: A Good Neighbor Policy," in Minerals Today, May 1990, p. 18.

King, Thomas. "The National Forests: 100 Years of Managing Minerals," in Minerals Today, August 1991.

Brown, David S. "Minerals in the Environmental Decade," in Minerals Today, May 1990.

U.S. Department of the Interior, Geological Survey. Estimates of Undiscovered Conventional Oil and Gas Resources in the United States. Washington, D.C: U.S. Government Printing Office, 1989.

U.S. Department of Agriculture, Forest Service. Report of the Forest Service. Washington, D.C: USDA Forest Service, annual publication.

U.S. Department of the Interior, Bureau of Mines. Mining and Mineral Operations in the Rocky Mountain States: A Visitor Guide. Washington, D.C: U.S. Government Printing Office, 1977.

National Coal Association. Facts About Coal, 1991.

Torrens, Ian M. "Developing Clean Coal Technologies," in Environment, July-August 1990, pp. 28-33.

Rogich, Donald G. "The Future of Materials: Plastic Component is Growing," in Minerals Today, June 1991, pp 30-32.

U.S. and World Resource Situation Estimates

U.S. Department of the Interior, Bureau of Mines. Mineral Commodity Summaries, Washington, D.C: Bureau of Mines, published annually.

U.S. Department of the Interior, Bureau of Mines. Minerals Yearbook. Washington, D.C: Bureau of Mines, published annually.

U.S. Department of State and Council on Environmental Quality. Global 2000 Report to the President. New York: Pergamon, 1980.

American Institute of Petroleum Geologists. Metals, Minerals, and Mining. Golden, Colo.: AIPG Foundation, 1981.

National Geographic. Special Energy Issue, February 1981.

Defries, Ruth S. and Thomas F. Malone, Eds. Global Change and Our Common Future. National Research Council publication. Washington, D.C: National Academy Press, 1989.

World Resources Institute. World Resources. New York: Oxford Press. Biennial publication.

Brown, Lester R. State of the World. Worldwatch Institute Reports. New York: W.W. Norton & Co., published annually since 1984.

Corson, Walter H. The Global Ecology Handbook. A Global Tomorrow Coalition supplement to the PBS environmental series. Boston: Beacon Press, 1990.

Anzovin, Steven, Ed. Preserving the World Ecology. New York: H.W. Wilson Co., 1990.

National Wildlife Federation. Conservation Directory, 1989. Washington, D.C.

Lean, G.D. Hinrichsen, and A. Markham. Atlas of the Environment. New York, Prentice-Hall, 1990.

Our Magnificant Earth: Rand McNally Atlas of Earth Resources. New York: Rand McNally, 1979.

Miscellaneous Sources

U.S. Department of Agriculture, Forest Service, SEAM. Creating Land for Tomorrow. Landscape Architecture Technical Information Series, Volume 1, No. 3, 1978.

Chalmers, J.A. Construction Worker Profile. Prepared for Denver Bureau of Reclamation Research Center by Mountain West Research, Inc., 1977.

Council on Environmental Quality. "Hardrock Mining on the Public Land." Washington, D.C.: U.S. Government Printing Office, 1977.

Ferrante, Lynn M. and Edward C. Thor. Predicting Events in the Development of a Coal Surface Mine in the West. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, GTR/PSW-41, June 1980, 11 pp.

Freudenberg, William. "A Social Social Impact Analysis of a Rocky Mountain Energy Boomtown," presented at the 73rd Meeting of the American Sociological Association, 1978; "Men and Women in an Energy Boomtown," in Rural Sociology, 46-2 (Summer) 1981.

Leistritz, F. Larry and Karen L. Maki. Socioeconomic Effects of Large-Scale Resource Development Projects in Rural Areas: The Case of McLean County, North Dakota. Fargo, N.D.: North Dakota State University Agricultural Experiment Station, 1981.

National Academy of Sciences, National Research Council. Technological Innovation and Forces for Change in the Mineral Industry, 1978.

Riemer, Jeffery W. Hard Hats: The Work World of Construction Workers. Beverly Hills, CA: Sage Publications, 1979.

Swanson, Bert E. and Richard A. Cohen and Edith P. Swanson. Small Towns and Small Towners. Beverly Hills, CA: Sage Library of Social Research, 1979, 280 pp.

Utah State Department of Community and Economic Development. "Socio-Economic Impact Mitigation: The Utah Approach," 1981. Also see: Colorado Department of Natural Resources. "Colorado's Joint Review Process," 1980.

Wilkinson, Kenneth P., et al. "Local and Social Disruption and Western Energy Development: A Critical Review" and "Divorce and Net Migration in the Old West," Pennsylvania State University Agricultural Experiment Station Journal Papers, 1981.